Energy, Mines and Resources Canada
Énergie, Mines et Ressources Canada

CANMET

Canada Centre for Mineral and Energy Technology
Centre canadien de la technologie des minéraux et de l'énergie

MINING RESEARCH LABORATORIES

ANNUAL REPORT

1986-1987

10540

Compiled and edited by
D.M. Hill

Mining Research Laboratories
Division Report MRL 87-20(TR) E

Canada

88-02147/

Foreword

This Annual Report contains an overview of the accomplishments of the staff of the Mining Research Laboratories division of CANMET during the 1986-1987 fiscal year. As a complete summary of the achievements during the period it is a valuable document. It is distributed widely within the private and public sectors.

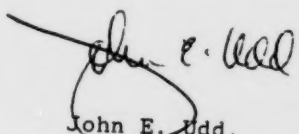
The report has been prepared by several members of the MRL staff. Project leaders have prepared summaries of the progress made on the projects which they supervised. The administrative staff have provided tabulations of: publications during the period; research contracts in effect; participation in technical committees; and staff. Donna Hill, MRL's Special Projects Officer, has compiled the information and has presented it in a much improved visual format.

As was the case during the previous year, 1986-1987 was a period of intense activity within the division. The work was at advanced stages on many of the research projects which had been initiated previously under the Mineral Development Agreements (MDA's) between the Federal government and the Provinces of Manitoba, Ontario and New Brunswick. New projects were initiated in Saskatchewan, and others proposed for implementation elsewhere. MDA and other external research, from a financial point of view, now represents about half of the work of the Division. There will be many important and lasting benefits from this; the most important being the relevance of research being accomplished through large-scale in-situ projects and the vastly improved communications channels and linkages with the industry.

During the year the new Elliot Lake Laboratory building became operational. The official opening, by the Honourable G.S. Merrithew, Minister of State for Forestry and Mines, took place on August 14, 1986.

One of the most visible research projects of the Division is the Canada/Ontario/Industry Rockburst project, which is under way at Elliot Lake. Work is now in progress at several Ontario mines, and in the development of improved microseismic and macroseismic monitoring systems.

Because of the increased importance which the industry is placing on mining research, the staff of the Division has maintained a high level of effort throughout the year. The resources of the Division are fully extended, however, and it becomes more and more difficult to respond favourably to the ever-increasing number of requests that are made for technical assistance. The staff is to be congratulated for the level of service which they have achieved and maintained. This report contains the details of their many accomplishments.



John E. Udd,
Director,
Mining Research Laboratories

Avant-propos

Ce rapport annuel présente un aperçu des réalisations du personnel des Laboratoires de recherche minière du CANMET au cours de l'année financière 1986-1987. En tant qu'exposé bref et complet des travaux réalisés durant cette période, il est un document précieux. Le rapport est distribué partout dans les secteurs public et privé.

Le rapport a été préparé par plusieurs membres du personnel des LRM. Les chefs de projets ont préparé des résumés des progrès accomplis dans les projets dont ils étaient chargés. Le personnel de l'administration a fourni une liste des publications parues durant l'exercice financier, des contrats de recherche en cours, des participants aux comités techniques et du personnel. Donna Hill, agent de projets spéciaux des LRM, a compilé les données et les a présentées dans un format qui se lit mieux.

Comme l'an dernier, l'année 1986-1987 a été une période d'activités intenses au sein de la Division. Les travaux sont avancés dans bon nombre de projets de recherche qui ont été amorcés antérieurement dans le cadre d'Ententes sur le développement minéral (EDM) entre le gouvernement fédéral et les provinces du Manitoba, de l'Ontario et du Nouveau-Brunswick. De nouveaux projets ont été créés en Saskatchewan et d'autres ont été mis de l'avant ailleurs au pays. Du point de vue financier, les EDM et la recherche externe représentent maintenant environ la moitié des travaux de la Division. Ces travaux procureront de nombreux avantages appréciables et permanents, dont les principaux sont la pertinence de la recherche effectuée par l'intermédiaire de projets in situ de grande envergure et l'amélioration marquée des communications et des relations avec l'industrie.

Au cours de l'année, le nouvel édifice abritant le Laboratoire d'Elliot Lake a ouvert ses portes. L'ouverture officielle de l'édifice a été présidée par l'Honorable C.S. Merrithew, ministre d'État aux Forêts et aux Mines le 14 août 1986.

Le projet de recherche conjoint Canada-Ontario-Industrie sur les coups de toit, qui est en cours à Elliot Lake, est l'un des projets les plus apparents de la Division. Des travaux sont actuellement effectués dans plusieurs mines de l'Ontario et portent sur la mise au point de systèmes de surveillance microsismique et macrosismique améliorés.

En raison de l'importance accrue que l'industrie accorde à la recherche minière, le personnel de la Division a déployé des efforts soutenus durant toute l'année. Par ailleurs, les ressources de la Division sont à leur maximum, et il devient de plus en plus difficile de répondre favorablement au nombre sans cesse croissant de demandes de soutien technique. Il convient de féliciter les employés pour le niveau de service qu'ils ont atteint et maintenu au cours de l'année. Le rapport présente en détail leurs nombreuses réalisations.

John E. Udd

John E. Udd
Directeur
Laboratoires de recherche minière

Mining Research Laboratories
Laboratoire de Recherche Minière

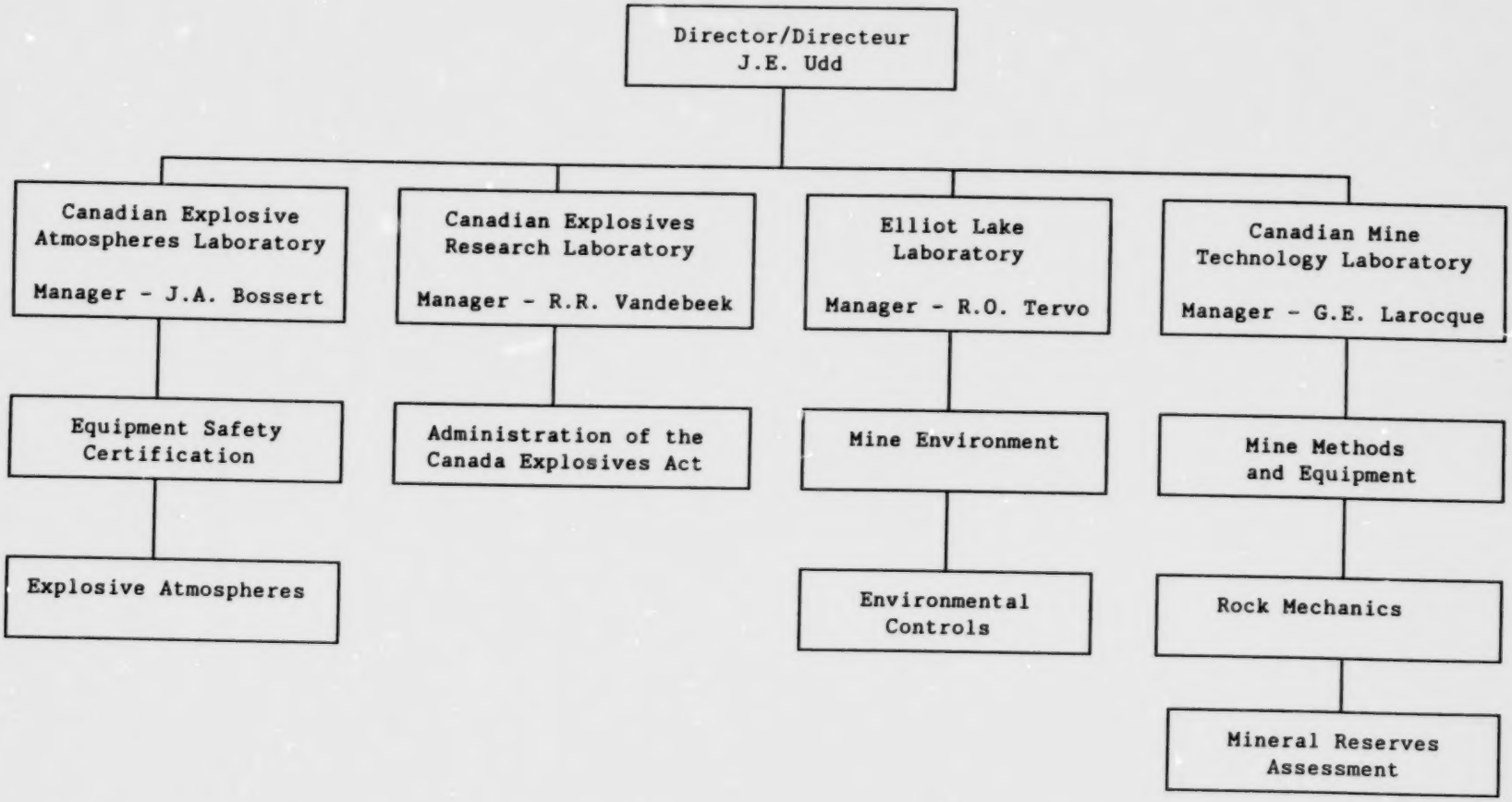


Table of Contents

Foreword i
Avant-propos ii
Organizational Chart iii
Fig. 1 - testing of high explosives vi
Fig. 2 - operation of a ballistic mortar vi
Fig. 3 - projectile impact test vii
Fig. 4 - thermal stability of explosives vii
Fig. 5 - test system control panel viii
Fig. 6 - high temperature/high permeability apparatus viii
Fig. 7 - stiff triaxial tests ix
Fig. 8 - high temperature/high permeability apparatus ix
Fig. 9 - dust explosion chamber x
Fig. 10 - flamability of conveyor belts x
Fig. 11 - Hartman Apparatus xi
Fig. 12 - Binary Gas Mixer xi
Administration 1

PART I - ADMINISTRATION OF THE CANADA EXPLOSIVES ACT

Explosives Technology

Highlights 3
Certification and Technical Advice 4
Explosives Research and Development 5

PART II - MINERAL AND ENERGY TECHNOLOGY

Highlights - Mine Methods and Equipment 11
Mine Methods and Evaluation 12
Advanced Mine Equipment Technology 13
Canadian Mining Technology Coordination 14
Matherials Handling and Operations Research 14
Evaporite Mine Methods 15

Highlights - Rock Mechanics 17
Rock Mass Characterization 18
Rock Properties and Support Systems 19
Numerical Model Development 20
Underground Nuclear Waste Repository 20
Instrumentation Development 21
Manitoba Mineral Development Agreement 22
Ontario Mineral Development Agreement 24
Mineral Reserves Assessment 26

Highlights - Elliot Lake Laboratory 33
Mine and Regional Stability 34
Rockburst Research 35
Respirable Dust/Ventilation 36
Radiation 38
Noise and Vibration 40

Appendices

Appendix A - Publications

Appendix B - Contracts and Research Agreements

Appendix C - Representation on Technical Committees

Appendix D - Contacts, Meetings, Field Trips & Joint Consultations

Appendix E - Cost Recovery

Appendix F - Professional, Technical & Administrative Staff
Staff Changes

ADMINISTRATION

Mining Research Laboratories
1986
Reports Listing for Administration

SP 87-1	Mining Automation II Proceedings of the Second Workshop Sponsored by CANMET/Mining Research Laboratories, Sudbury, Ontario, October 17, 1986	J.E. Udd
SP 86-6	Mining Automation: Proceedings of a workshop sponsored by CANMET/Mining Research Laboratories and the Ontario Centre for Resource Machinery Technology, Sudbury, March 12, 1986	J.E. Udd J.C. Wilson
TM&E/LRM 86-5(OPJ)	La Recherche Minière à CANMET: Son Impact Industriel	J.E. Udd N.R. Billette
M&ET/MRL 86-22(J)	Some examples of instrumentation for stability monitoring in Canadian underground hard rock mining	J.E. Udd
M&ET/MRL 86-31(OP)	Some thoughts on minerals industry education for the 21st century	J.E. Udd
M&ET/MRL 86-36(OP)	Speech to Laurentian University students, March 12, 1986	J.E. Udd
M&ET/MRL 86-53(TR)	Mining Research Laboratories Annual Report 1985-1986	D.M. Hill
TM&E/LRM 86-53(TR)	Rapport Annuel Des Laboratoires De Recherche Minière 1985-1986	D.M. Hill
M&ET/MRL 86-56(OP)	Recent developments in remote mining systems	N. Burtnyk J. Scrimgeour J.E. Udd J. Pathak
M&ET/MRL 86-63(OP)	Summary reports of progress on tripartite USBM/MOL/CANMET research projects, 1985-86	J.E. Udd E.D. Dainty P. Mogan L. Geller
M&ET/MRL 86-67(INT)	Summary reports of progress on 1985/86 Mineral and Energy projects Mining Research Laboratories	J.E. Udd E.D. Dainty G.E. Larocque J. Pathak D.M. Hill

1986 MRL Reports Listing (Cont'd)

M&ET/MRL 86-112(TR)	Mining Research Projects (except for coal) FY 1986-87	D.M. Hill
TM&E/LRM 86-112(TR)	Projets de Rechereche Minière (Autres que ceux qui portent sur le charbon)	D.M. Hill
M&ET/MRL 86-118(INT)	Report on a visit to the Tytyri Limestone Mine, Lohja, Finland	J.E. Udd
TM&E/LRM 86-123(OP)	Historique et perspectives des piliers de surface Canadians	J.E. Udd M.C. Bétournay
M&ET/MRL 86-129(J)	Monitoring of stability conditions at Falconbridge's Strathcona Mine REVISION OF DIVISION REPORT M&ET/MRL 85-93(TR)	J.E. Udd S. Bharti

PART I

ADMINISTRATION OF THE CANADA EXPLOSIVES ACT

CANADIAN EXPLOSIVES RESEARCH LABORATORY

Highlights

During 1986/87, the Canadian Explosives Research Laboratory examined 445 explosives for authorization under the Canada Explosives Act. Work continued into those factors that cause ammonium nitrate to detonate. A specialized explosive system has been designed to remove the cones from a tricone bit to permit in-situ sampling of ground water.

The laboratory continued its investigation into the thermal properties of explosives, in particular, studying the properties of trinitrotoluene (TNT). Several equations of state were evaluated to assess their impact on predicting detonation properties and fume compositions of a large variety of slurry and emulsion explosives. The completion of the contract on the propagation sensitivity of commercial explosives in 15cm boreholes identified that the initiating system, most probably the detonator, is responsible for most cross-deck propagations in decked blasting.

SUB-SUB ACTIVITY: EXPLOSIVES TECHNOLOGY

CERTIFICATION AND TECHNICAL ADVICE

Objectives

The objectives of this project are; to confirm the safety characteristics of all submitted explosives for authorization under the Canada Explosives Act, to provide technical advice on the manufacture, storage and transportation of explosives, and to investigate accidents.

Background

The Certification and Technical Advice project of the Explosives sub-activity has been developed to fulfill the requirement of "chemist" specified in Section 14 of the Canada Explosives Act. Since the promulgation of the Explosives Act in 1919, the capability has existed to certificate explosives, to advise on technical problems of explosives and to investigate accidents. This capability has continuously been developed through contacts with manufacturers' laboratories, contracted research projects, in-house development projects and international contacts. Responsibilities under the project continue to increase because of technical advances in formulation and manufacture, increased concerns about the safety of transportation and storage of high hazard fireworks and propellants, and added international responsibilities.

Achievements

During the year, 445 new explosives were examined for authorization. These involved some 1832 sample units of work. Corresponding figures for the years 1985/86 were 351 and 2528, respectively, and for 1984/85 were 347 and 2544. Details of the samples by Classes are to be found in the "Summary of Samples Examined" section of this report. Compared to the previous two years, there has been a significant increase in the total number of samples. However, the mix of samples has changed with fewer high explosives and ammunition samples being submitted but with a significant increase in the number of Class 7.2.1 and 7.2.2 Fireworks. The large increase in Class 7.2.2 Fireworks was primarily a result of the fireworks display held nightly at Expo '86.

There were no major accidents in explosives manufacture during the past year which required the laboratory's involvement. It is through the effects of industry and government that no major accident has occurred since August of 1980.

The laboratory continued its work on those factors that cause explosions with ammonium nitrate. Sealed vessel tests containing 2kg of ammonium nitrate have been completed. The data are currently being analyzed and two reports will be published during 1987/88. The analytical study of the projects formed by the reaction of ammonium nitrate with various metals has been completed (report in draft form). Studies into the explosive properties of the metal-ammonium nitrate reaction products are planned.

The laboratory is just completing a large scale test of a Schedule IV container which is designed to transport detonators safely on a truck carrying other explosives. The container, containing 1200 detonators, will be tested to evaluate its resistance to a massive fire. A report and videotape will be available in the new fiscal year.

As a result of the laboratory being requested to dispose of a large quantity of display fireworks left over from the International Fireworks Festival in Montreal, the project milestone on evaluation of propagation hazards of Class 7.2.2 display fireworks has been delayed until July, 1987. The laboratory will now be able to complete a much more thorough series of tests. Significant interest in the proposed tests has been expressed by international authorities.

The laboratory has been upgrading its test facilities for testing ammunition and for determining the projectile impact sensitivity of high explosives. Three reports have been published detailing the improvements (ACEA/MRL 86-46(TR), 86-93 and 86-73).

An explosive device, to remove the cones from a tricone bit to permit in-situ sampling of ground waters, has been designed and field tested for the Geological Survey of Canada (a draft report has been prepared). A specialized container is being designed and evaluated for the RCMP to transport forensic explosive samples. The work should be completed shortly.

EXPLOSIVES RESEARCH AND DEVELOPMENT

Objectives

Explosives R&D's main goal is to advance the technology related to the manufacture, storage, transportation and use of explosives.

Background

Explosives R&D at CANMET is primarily directed at furthering our technical capability to reduce safety and health risks involved in working with explosives.

CANMET efforts over the past few years have been directed to the development of mathematical models to predict explosives properties and detonation parameters in order to avoid the need for extensive field testing of explosives to determine, for example, the levels of toxic fumes produced on detonation. A new fume testing facility is under construction to measure experimentally toxic fumes. Studies are underway to develop a mathematical model to predict the consequences of a vehicle transporting explosives being involved in a collision (low velocity impact). The effects of temperature and fire on explosives during manufacture, storage and transport are being investigated.

Methods to determine properties of explosives are continually being developed or improved as new types of explosives are marketed in order to contribute to risk analysis methodology. New types of explosives are studied in depth to fully characterize them. An additional thrust will be the study of properties of explosives including detonators on their use in mining and civil engineering projects. These properties will include propagation sensitivity and time delay of detonators.

In cooperation with other countries through the United Nations, a unified international classification system is being developed to classify explosives for transport purposes. The Canada Explosives Act will shortly be changed to incorporate this new system. A series of studies is underway to ensure that no difficulties in classification arise when the conversion is made.

Achievements

During 1986/87, CERL continued its long term study into the thermal stability of explosives. The thermal stability evaluation of sellited and unsellited trinitrotoluene (TNT) using accelerating rate calorimetry (ARC) was completed. A paper on the evaluation of thermal runaway of high explosives using ARC was presented at the 41st Calorimetry Conference (ACEA/MRL 86-91(OP)).

The installation of the new fume testing facilities is essentially complete. Evaluation trials of this new facility will commence shortly. A report was issued on the evaluation of an exploding wire technique as a calibrated energy source for initiating explosives (ACEA/MRL 86-44(TR)). A user's guide was prepared for the use of a TI microcomputer with the Cyber 730 mainframe computer (ACEA/MRL 86-120(INT)).

Work on the modification to a thermohydrodynamic model (Tiger Code) continued. The detonation properties and fume compositions of a large variety of slurry and emulsion explosives were compared using several equations of state. Additional work was done on the theoretical calculation of thermal decomposition of explosives from hot spot initiation (ACEA/MRL 86-137(TR)).

To complement its in-house research, the laboratory also supports research under contract. Two contracts were completed over the past fiscal year and a third has been extended until November 1987. The first contract completed was the experimental verification of a high velocity impact model. As the details of the works were fully described in last year's annual report, they will not be repeated here. Based upon the results of this work, two papers were presented - one at the International Symposium on Intense Dymanic Loading and Its Effects at Beijing, China (ACEA/MRL 86-47(OPJ)) and the second at the 22nd Explosives Safety Seminar, Anaheim, U.S.A. (ACEA/MRL 86-146(OPJ)). The work has been very well received.

A second contract on the propagation sensitivity of commercial explosives in 15cm diameter boreholes was completed in December 1986. The results of this work identified that it is the initiating system, most probably the detonator, that is responsible for most cross-deck propagations in decked blasting. A paper on this work was presented at the Society of Explosives Engineers Conference (ACEA/MRL 86-150(OPJ)).

The third contract on the development of a theoretical model for predicting the low velocity impact sensitivity of bubble-sensitized slurry explosives has been extended from a completion date of March 1987 to November 1987 at the request of the contractor. It is clear that even with small diameter cap sensitive slurry explosives, projectile impact velocities of approximately 20-25 m/sec cannot produce detonation. During this period, attention was concentrated on the experimental work to determine the reaction threshold of explosives due to low velocity impact. The experimental system being used is a modified gap test. The first explosive to be studied was pressed RDX as a standard.

SUMMARY OF SAMPLES EXAMINED AT CERL

Calendar Year 1986

	No. of Samples	Estimated Sample Units of Work
High explosives - Classes 1, 2 and 3	46	920
Ammunition - Class 6.1	23	184
- Classes 6.2 and 6.3	7	56
Pyrotechnic mixes - Class 7.1	--	---
Fireworks - Class 7.2.1	280	280
- Classes 7.2.2 to 7.2.5	83	332
Miscellaneous	6	60
TOTAL	445	1832

Mining Research Laboratories
1986
Reports Listing for CERL

ACEA/MRL 86-21(TR)	Studies into the thermal stability and reactivity of ammonium nitrate Part 2: Solid state decomposition of ammonium nitrate	P. Lee K. Ketcheson R. Vandebeek
ACEA/MRL 86-23(J)	Kinetic studies of thermal decomposition of tetryl using accelerating rate calorimetry Part I. Derivation of the activation energy for decomposition.	P. Lee M.H. Back
ACEA/MRL 86-24(J)	Kinetic studies of the thermal decomposition of tetryl using accelerating rate calorimetry Part II. Products and mechanism of the reaction	P. Lee M.H. Back
ACEA/MRL 86-29(TR)	Studies into the thermal stability and reactivity of ammonium nitrate Part I: The reactivity of various metals with ammonium nitrate studied by accelerating rate calorimetry	P. Lee R. Vandebeek
ACEA/MRL 86-44(TR)	Evaluation of exploding wire technique as a calibrated energy source for initiating explosives	E. Contestabile E. Shimoon
ACEA/MRL 86-46(TR)	CERL's facilities for determining ballistic properties of ammunition	T.R. Craig
ACEA/MRL 86-47(TR)	Numerical modelling of the high velocity impact sensitivity of commercial slurry and emulsion explosives	K.K. Feng R. Vandebeek A. Bauer P. Katsabanis J. Moroz D. Duncan
ACEA/MRL 86-73(TR)	CERL's projectile impact testing facility	E. Contestabile T. Craig P. Larsen
ACEA/MRL 86-91(OP)	Evaluation of thermal runaway of high explosives using accelerating rate calorimetry	P. Lee R. Vandebeek K. Feng
ACEA/MRL 86-93(TR)	CERL's sporting ammunition testing facility	E. Contestabile R. Vandebeek T. Craig
ACEA/MRL 86-108(TR)	Measuring the detonation velocity of explosives	E. Contestabile T. Craig D.L. Cox E. Nagy

1986 MRL Reports Listing (Cont'd)

ACEA/MRL 86-120(INT)	Application of the Cyber 730 mainframe computer with the TI micro-computer	I.W. Reilly
ACEA/MRL 86-137(OP)	Theoretical calculation of thermal decomposition of explosives from hot spot initiation	K. Feng D. Jones
ACEA/MRL 86-146(OPJ)	High velocity impact sensitivity of commercial slurry and emulsion explosives	K.K. Feng R.R. Vandebeek A. Bauer P. Katsabanis J. Moroz
ACEA/MRL 86-150(OPJ)	Evaluation of propagation sensitivity of commercial explosives in large diameter holes	K. Feng R. Vandebeek A.W. Bauer A. Bauer
M&ET/MRL 86-151(TR)	Explosibility tests on ferrosilicon dust	K.C. Cheng D. Cox

Don Cox (Technologist)

tests a high explosive
on a BAM friction machine

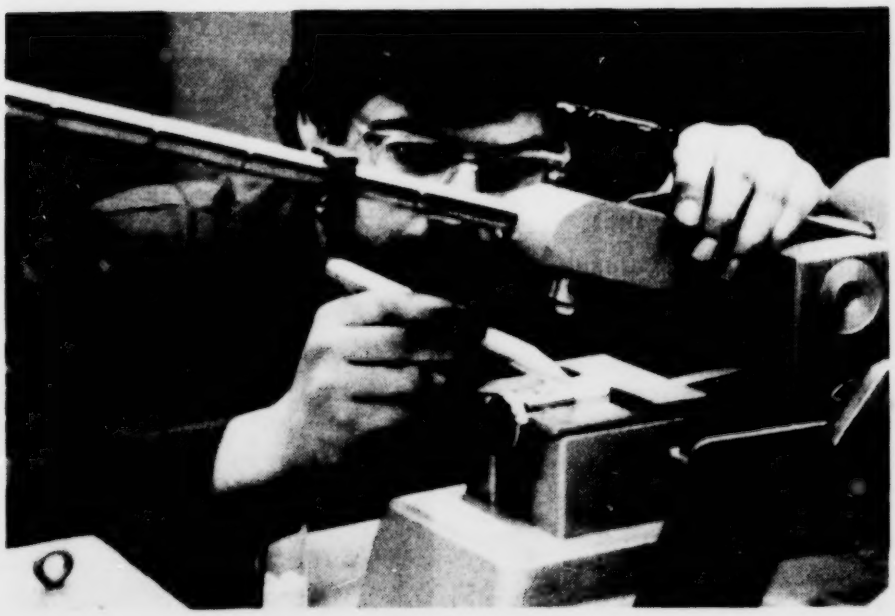


Fig. 1

Don Cox operates a
ballistic mortar used
to test the strength of
an explosive

Fig. 2

Terry Craig
(Technologist)

loads cartridges
for the projectile
impact test

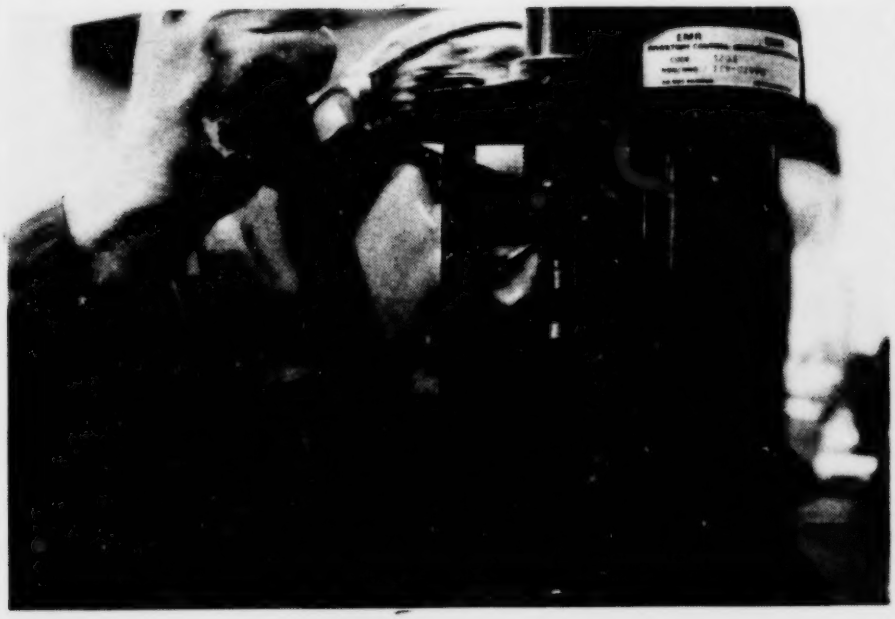


Fig. 3

Dr. K.K. Feng
(Research Scientist)

ARC (Accelerating Rate
Calorimeter) is used for
testing the thermal stabilit
of explosives

Fig. 4

PART II

MINERAL AND ENERGY TECHNOLOGY

MINING METHODS AND EQUIPMENT

CANADIAN MINE TECHNOLOGY LABORATORY

Highlights

Mine Methods and Equipment

Through a contract with J.S. Redpath Limited, a manual entitled "Estimating Preproduction and Operating Costs of Small Underground Deposits" was prepared and made available to the general public. The manual was specifically developed to permit junior mining companies, prospectors, and independent entrepreneurs with limited financial resources to carry out the preliminary assessments of the economic viability of promising finds. While the manual has attracted the interest of its intended users, an interest has also been shown in the manual by universities, governmental agencies, and mining company staff members.

SUB-SUB ACTIVITY: MINING METHODS AND EQUIPMENT

MINE METHODS AND EVALUATION

Objectives

Estimates of planned and projected production capabilities of Canadian uranium mines are prepared annually. On a continuing basis, related to this activity, mineability and mine operation economic criteria are being developed and evaluated for hardrock mining situations in Canada.

Background

Engineering studies are carried out on an annual basis to determine the production capabilities and production costs of producing Canadian uranium mines. In addition, the future production capabilities and costs of Canadian properties are estimated. These studies are carried out in support of the Ore Reserve Evaluation Group and its preparation of an annual report for URAG.

To meet the above commitments it is essential for CANMET to acquire realistic production cost data in order to develop adequate mine operations evaluation procedures and to establish a base of unit productivities related to existing and developing mining technologies.

Such expertise, supported by the available databases, is applicable to all hardrock mining operations and is regularly used to carry out engineering studies on potential or existing mining operations to meet policy requirements.

Achievements

A report was prepared for internal departmental use on present production capabilities of Canadian uranium mines and the future production capabilities of existing uranium mines and those in the planning stage. Visits were made to members of operating uranium mines and companies with well defined uranium ore bodies to gather technical information for the report.

A manual, on the subject of estimating the preproduction and operating cost of small underground deposits, has been developed under contract. This manual, which permits preliminary assessment of the economic viability of promising finds, was developed for use by junior mining companies, proprietors and independent entrepreneurs. Over 450 copies of the English version have already been distributed; a French version will be available shortly. A diskette version of the analysis contained within the manual, to estimate small mine capital and operating costs, is in production for use on IBM-PC compatible hardware.

A large number of engineering studies and investigations were carried out in order to respond to departmental and non-departmental requests for information on various aspects of mining technology.

ADVANCED MINE EQUIPMENT TECHNOLOGY

Objectives

Studies are carried out to assess the productivity impact of new world mining equipment developments and other developments in pertinent advanced technologies (i.e., robotics) on mining systems used in Canadian mines. State-of-the-art reports are prepared on mine equipment technology for dissemination to the mining industry. An additional objective, on the basis of identified benefits to the mining industry plan, is to review and promote the development and demonstration of new mine equipment/equipment systems relevant to all aspects of mining.

Background

Improvements in safety and productivity often result from improvements in mining equipment. A good example, in this regard, is the replacement of separate loading and hauling equipment in mining by load-haul-dump units. The introduction of large hole drill machines in underground mining has permitted a reduction in the number of sub-levels required for drilling. Mine design has evolved in the past to accommodate and take advantage of new equipment developments. Further evolution will be required to take into consideration future equipment developments with respect to portable crushers, conveyors, tunnelling machines, pre-concentrators, etc.

Achievements

A contract study has been completed which established the technical feasibility of drilling or breaking hard rock using a cavitating hydro impactor. Field trials using a conventional production drill were carried out in abandoned open pit mines of Falconbridge Ltd. and Inco Ltd. at Sudbury. The study also resulted in the development of a new, shock-resistant, high pressure water seal, for which a patent application has been made.

The project directed at the development of critical accessories for the automation of down-the-hole drills has been successfully completed. The accessories, which were installed on a Continuous Mining Sytems CD-90 Drill, were field tested at Inco Limited's Research Mine. Vadeko Limited, who developed the accessories under contract to CANMET, plan to proceed with their commercialization.

Software related to the large diameter underground blast hole stope design procedures developed for CANMET under contract in fiscal year 85/86 was modified for use on IBM-PC equipment and tested in underground mines of the Sudbury basin in fiscal year 86/87. The procedures and IBM-PC software have, as well, been provided to Inco Thompson for their use on MDA bulk mining optimization studies. A user's manual has been prepared by CMTL staff to make the procedures and software generally available to the Canadian mining industry.

CANADIAN MINING TECHNOLOGY COORDINATION

Objectives

Research studies are carried out to develop and maintain a national information bank on current and developing mining technology in the Canadian mining industry and other related organizations. The data are made available to government and industry on a continuing basis. The ultimate objective is to promote cooperation and improve efficiency.

Background

There are many improvements in mining technology being developed on a continuing basis within operating mines, universities, government and other R & D organizations. Sometimes these developments, specifically intended for one particular organization and potentially beneficial to others, are never published. There appears to be a limited interchange of information on projects which are in progress and for which results may be available. An ongoing communications network assembling and disseminating such information would be a valuable contribution to mining technology development in Canada.

Achievements

The 1986 Index of Mining Technology Projects report has been produced on schedule. Additional mining companies, agencies, universities, etc., were visited in preparation for the 1986 index. The number of identified projects in the index has risen to 520 from 430 in the 1985 Index.

MATERIALS HANDLING AND OPERATIONS RESEARCH

Objectives

New concepts for material handling systems which provide improvements in productivity and safety, are being developed for use in underground and open pit mines; new ventilation models are being developed for the determination of heat transfer in different media and mine segments. Mine simulation computer graphics packages for use in the optimization of various mine functions in mine design are also being developed.

Background

The metals price depression of the 1980's placed considerable pressure on the Canadian mining industry to maintain its advance in mine technology in order to remain competitive. Increased utilization of mathematical modelling and computer control can lead to more optimal usage of mine equipment, such as

trucks in open pit haulage operations. It has been estimated that successful automation and robotization of haulage trucks in a large open pit mine would result in a yearly operational saving of $150,000 to $200,000 per unit.

Achievements

Two reports were prepared during fiscal year 86/87: Division Reports M&ET/MRL 86-154(TR) and M&ET/MRL 86-157(TR). The first report presented a description of a general theory of ore blending, while the latter reviewed alternatives to the present common use of open pit truck haulage systems.

EVAPORITE MINE METHODS

Objectives

Contract research is being carried out in the areas of ground control, environmental control, and productivity. The objective is to increase potash recovery over current levels in Canadian mines.

Background

On May 17, 1983 the Minister of Energy, Mines and Resources announced the coming into force of the two (2) year START Program (Short-Term Aid in Research and Technology) to assist the Canadian mining industry.

One of the thrusts provided for under START was research and development contracts with short-term industrial benefit. The current recovery rate of Saskatchewan potash is 40% and, though profitable, represents a significant loss of resources as well as profit due, in part, to increased underground transportation.

A two-year program of contract research under START ($250k/year), to aid the potash industry was completed by MRL with the participation of the potash industry. A total of eight contracts which addressed questions of mine design ground control and dust monitoring were completed. Technology transfer continues to be in process.

Present studies, outside the framework of START, are directed towards monitoring excavation behaviour by numerical modelling on the basis of material properties determined in field and laboratory studies.

In 1985, ground control research with respect to potash mining expanded into New Brunswick as part of the Canada/New Brunswick Mineral Development Agreement. This multi-year research program is directed at developing the technology/knowledge essential to use salt waste as a backfill material. If structural support provided by salt back fill proves effective, increased ore recovery can be expected.

Achievements

Technology transfer seminars for the newly developed Georoc Numerical Model for use in the Canadian Potash industry were given at Saskatoon, Saskatchewan May 21-22, and Sussex, New Brunswick May 27-28 by G. Herget, Y. Yu and key contractor personnel.

Work under the contract to Denison-Potacan, Sussex, N.B., to establish the level of wall and roof support derived from backfilling, progressed satisfactorily. A new contract was awarded to International Minerals and Chemicals Company to identify absolute ground stresses and stresses induced by mining of potash panels.

Progress was made in an on-going review of underground potash mining methods with the purpose of achieving lower mining costs and greater predictability of water inflow with respect to Saskatchewan potash formations. The mining company concerned is seriously contemplating a pilot study using shortwall mining.

The contract awarded to Central Canada Potash to carry out a field test program to evaluate the use of waste salt backfill in Saskatchewan potash mine was completed. The backfill methods were used successfully to seal off two brine inflow areas into the mine.

ROCK MECHANICS

CANADIAN MINE TECHNOLOGY LABORATORY

Highlights

Rock Mechanics

CMTL's Instrumentation Development Group, under Dr. Herget's leadership, has developed the "MRL Strain Monitoring System". The system, which is highly sensitive as well as stable, permits accurate monitoring of stress changes occurring in rock structures adjacent to stopes and headings which are being mined. The system, which has been successfully used in a field rock mechanics investigation, will shortly be used as part of the field instrumentation in two other studies. A patent application has been made.

SUB-SUB ACTIVITY: ROCK MECHANICS

ROCK MASS CHARACTERIZATION

Objectives

A handbook on surface crown pillars for safe and economic design, including guidelines for the design process, is being developed to meet the requirements of the mining industry. Background investigations are being carried out on underground stability where geological structure and gravitational forces are the major cause of failure. Empirical, statistical and deterministic models are being developed to predict stable structures.

Background

It is recognized that some specific structures in mining have special stability and support requirements. Surface crown pillars constitute a component of those mine structures requiring special consideration.

Special attention is required to delineate the reasons for stability/instability of such structures and the best methods of retrieval of critical parameters, evaluation of stability, and support requirements in the context of the operators mining activity.

When properly included in a valid design approach, rock mass characterization provides the focus for dealing with surface crown pillars. Because of the uniqueness of these mine structures, in a material and comparative sense, such characterization must employ methods and equipment used in the field of mining and civil engineering and would benefit from the availability of a surface crown pillar specific characterization system. Such a system would be applicable to large, multiple openings common in mining and would supply an understanding of how the rock mass interacts with support systems such as backfill.

Achievements

Research on various mine backfills is continuing at MRL. Special surface crown pillar cases are being studied (laminated rock, Niobec Mine, Quebec; intensively weathered rock, Les Mines Selbaie, Quebec) which, when combined with 24 completed case studies of Canadian surface crown pillars (located in Manitoba, Ontario, Quebec and New Brunswick), will provide a cross section of various rock mass settings and characteristics. A service contract has provided MRL with a computer based core logging system with the potential to serve as the base for a rock mass characterization system.

Progress has been made towards developing a technology for rock mass characterization and the development of deterministic models to analyze the standard stability of surface crown pillars. An analysis of the case study results, an outline of the planned surface crown pillar handbook, and the Niobec Mine geotechnical study were presented at a CANMET/CRM/QMMA sponsored Colloquium on Surface Crown Pillars.

ROCK PROPERTIES AND SUPPORT SYSTEMS

Objectives

Research investigations are carried out to establish the peak and residual strength, deformational, and other rock properties required in ground control investigations. Laboratory test procedure guidelines and equipment are being developed to specifically meet the requirements of such investigations.

Background

An increasing portion of Canadian underground mining in the future will take place under high stress. Under such conditions, the post-failure strength and deformational properties of the rock materials must be taken into consideration in design.

Ground support requirements under deep mining conditions requires research. The effectiveness and limitations of present underground support systems need to be established. New methods of ground support must be developed.

The increased accuracy and sophistication of analytic methods related to mine design, requires that more exact constitutive equations concerning rock strength and deformation properties be developed. New test methods and procedures must be developed to permit laboratory determinations of the required properties.

Achievements

Material property investigative programs have been developed and used to meet the specific mine rock information requirements of ground control investigations being carried out at the Detour Lake, Central Canada Potash, Niobec, Lingan, and Prince Mines.

The installation of the new servo-controlled rock testing system has been completed. Good progress is being made towards the development of the procedures which will be used to determine the peak and post-failure strength and deformational properties of mine rock.

Two test programs have been completed as part of the process of developing test procedures to establish the strength and deformation of rock joints under underground mine stress conditions. The size effect of joint roughness has been investigated by a drill shear method. Joint residual strength properties have been established using the MRL confined shear test methods. Test results for the two programs are presently being analyzed.

Based on a novel concept, the development of a support system design and evaluation method has been completed. With the method, design drafts can be used to determine effective and economic support systems in specific rock mass conditions.

NUMERICAL MODEL DEVELOPMENT

Objectives

Analytic numerical modelling studies are regularly carried out as part of applied ground control investigations. New numerical models and software packages are developed or modified with improved capabilities to simulate mine geometry, sequence, rock mass behaviour and artificial support behaviour. A particular effort is being made to develop analytic packages suitable for use by small mines.

Background

The prediction and evaluation of rock mass response to mining is becoming progressively more important in mine design and planning.

Information provided by such studies can be used by mine staff in the selection of mining methods, layouts, stope and pillar dimensions, and mining sequence taking more fully into consideration ground control and support requirements. Numerical models are finding increasing use in mining to predict ground response to mining and to evaluate the effectiveness of support systems. With time, the models are becoming more sophisticated and better able to simulate actual mine conditions in terms of mine geometry, mine sequencing and material properties. Further research leading to the development of improved models is required if mining is to fully benefit from this technology.

Added to MRL's Sun workstation; the Sun's operating systems was brought up to level 3.2, and the GKS graphic package implemented.

UNDERGROUND NUCLEAR WASTE REPOSITORY

Objectives

The general objective is to develop, by 1989, field and laboratory investigational methods, equipment and procedures to assess rock formations for high level radioactive waste disposal in terms of their thermal, mechanical and ion transport properties and to carry out related investigations on research area formations and at the planned underground research facility site. The studies carried out in research area formations and the underground research facility site will be used in pathway analysis studies related to concept assessment and in the design of the underground facility.

Background

Disposal of spent fuel rods will become a critical aspect of nuclear electricity generation. EMR's program is an integral part of a larger Atomic Energy of Canada Limited's (AECL) directed Canadian Nuclear Fuel Waste Management Program (NFWMP) to find safe and effective methods of disposing of high level nuclear wastes.

The current participation of EMR in the NFWMP has evolved over the past ten years from an initial request, in 1973, from AECL to EMR for geoscience advice on disposal by burial. An integrated geoscience sub-program has since been developed at EMR in support of the NFWMP with current active participation by CANMET, the Geological Survey of Canada (GSC) and the Earth Physics Branch (EPB). The sub-program is structured into geology, geophysics and rock properties activity, and is mainly focussed on igneous formations.

At present, four research areas on plutonic structures located in Manitoba and Ontario are being used to investigate the concept of disposal of high level nuclear waste by burial. As well, an underground research laboratory (URL) is under construction near the Whiteshell Nuclear Research Establishment (WNRE) in Manitoba to carry out large-scale underground experiments.

Achievements

Evaluation of the Barton-Bandis Joint Model continued with studies to investigate form testing scale effects on rock joint shear strength. This has included direct shear tests on small block samples as well as calibration of the large scale shear box which will be used to study the shear behaviour of larger block samples. Additionally, index testing and characterization studies were carried out on 200mm diameter jointed samples obtained from the URL shaft. The results of this work will eventually assist in relating laboratory small scale rock joint behaviour to in situ rock mass conditions.

Several suites of rock were tested in uniaxial compression to discover if any significant anisotropy exists in the strength and deformation properties of Lac du Bonnet granite specimens obtained during shaft sinking at the URL.

The mechanical and thermomechanical rock properties determined to date by MRL for three research areas being studied within the AECL's Nuclear Fuel Waste Management Program were summarized and statistically analyzed for inclusion in level 2 concept assessment documents.

INSTRUMENTATION DEVELOPMENT

Objectives

Investigations are carried out to identify the existing and developing field geotechnical investigation requirements of the mining industry. Research studies are undertaken to design and develop instrumentation to meet some of the more pressing needs. Field testing of developed instrumentation is carried out to assure that it meets industry's requirements.

Background

A wide variety of geotechnical instrumentation has been developed over the years for use in mines, but very little objective testing and field evaluation has been carried out. Because of MRL's access to mines and its expertise, MRL is in an excellent position to evaluate such instrumentation in terms of performance criteria and usefulness.

There is also a need to develop several new instruments/instrument systems for use in ground control studies related to mining. Included are the following: a small diameter borehole inspection T.V. camera for stability evaluation and design; force meters for blast vibration studies; and meters to determine the in situ creep/deformation properties of potash. MRL can very effectively participate in the development of such new geotechnical instrumentation for the mining industry.

Achievements

Work has been completed in upgrading a small, side-looking borehole T.V. camera so that it is suitable for use in the most harsh underground mine environments. Since upgrading, the camera has seen repeated use in wet boreholes and brine-filled boreholes. It has been established as an extremely reliable unit in these field applications.

A new vibrating wire strain monitoring unit has been developed. Six prototype units have been used in Niobec Mine to determine ground reaction during drift development. Initial results are encouraging and further use of the units is planned in other field ground control investigations. A stress measurement demonstration unit was built for the award-winning CANMET exhibit.

MANITOBA MINERAL DEVELOPMENT AGREEMENT

Objectives

Design guidelines and safer scaling procedures are being developed for the Vertical Block Method (VBM). With respect to the design of deep underground openings, a geotechnical database system and numerical analytic package is being developed. Ground stability evaluation criteria are being developed with particular reference to en echelon lensed orebodies. An underground mine communication system is to be installed and evaluated for general use in multi-level, hard rock metal mines.

Background

Cut-and-fill mining is used extensively in northern Manitoba. When used in poor ground conditions, however, serious production and safety hazard problems can be realized. With this method, miners must work directly underground with caving potential. Because present cut-and-fill mining requires extensive scaling, heavy support, blast control and skilled labour, modified or new methods, such as VBM methods, are being investigated for their replacement potential.

Improved ground control also requires a better understanding of rock mass response to mining and the causes of instability. Therefore, studies in the area of rock mass behaviour, mine stability, numerical modelling and improved mining technology are planned.

Safety in underground mines would benefit from the availability and use of more effective radio communications systems. Warning systems for fires based on the injection of stench gas in the mine air are inadequate for working areas which receive limited ventilation. A reliable communications system will be installed and evaluated which will permit mine-wide voice contact with personnel.

Achievements

Six mineral development agreement tasks were under contract to Manitoba Mines in 1986/87:

1. Underground Mine Communication Systems For Isolated Areas in Mines

The pilot study, reviewing both voice and data transmission, has been completed. Action has been taken to procure a full-scale mine and shaft communication system with both voice and data capabilities. It is anticipated that installation will begin in April 1987.

2. VBM Design Guidelines, Scaling Techniques and Hangup Removal

The review of cut-and-fill mining practices in Manitoba was completed and a progress report submitted.

Analytic studies have been initiated to evaluate the stability of stopes 1401-301, 3601-231 and 803-340 at Inco's Thompson Mine. Preliminary analytic studies of stope 1401-301 have been completed and a report prepared. Analytic studies with respect to all three stopes are to be completed by March 1987.

With regard to hang-up removal in ore passes, developing and testing of avalanche control skills/projectiles for this application are under evaluation. Explosive charges of up to 1kg are being used in the evaluation.

With regard to scaling, the development and testing of a hand-held pneumatic impactor for this function is behind schedule. Modifications are required to reduce the weights of the units before further field trials are undertaken.

3. Geotechnical Data Base in Ground Control in Underground Mines

With respect to the geotechnical data base, the data retrieval system has proven satisfactory in the tests conducted. Work is continuing on developing a mine data base. Work is in progress on interfacing the data retrieval system with numerical model pre-processing programs.

Development of BEAP (a three dimensional boundary element program) has been completed and a two volume progress report submitted. Results from preliminary testing of BEAP or problems with closed solutions are good.

Good progress is being made in the development of a displacement discontinuity element program, BEAPDD. This will be a sister package to BEAP. When both packages are running satisfactorily, these will be combined in a third and final package, to be called BEAPM (Boundary Element Analysis Package - Mixed). The core program BEAP has been installed on INCO, Thompson's computer for further testing.

4. Ground Stability Evaluation with Particular Reference to En Echelon Lensed Orebodies.

Geotechnical monitoring of test stopes is continuing. Flatjacks and remote slough meters have been added to complement previously installed extensometers and stress meters. Instrumentation is being developed to transmit data from remotely located extensometers and vibrating wire stress meters.

Design guidelines for predicting stope dilution have been completed and a progress report issued.

Work is continuing on stope stability back analysis studies and the development of rock mechanics computer modular systems. The modules or numerical codes and post-processing graphics programs have been completed. A ground support module is being developed.

5. Blast Optimization for Large Open Stope Mining

A review of presently available technology and suitability use in blast decision for large open stope mining has been completed. Two tested stopes have been selected in the planned field studies involved.

6. Delayed Backfill Consolidation

A contract with Hudson Bay Mining and Smelting is now under way. The first stage, to be completed by the end of fiscal year 1986/87, will define the problems and study criteria. It is anticipated that the second phase will involve laboratory and onsite testing of fill materials and stope trials with fill materials.

ONTARIO MINERAL DEVELOPMENT AGREEMENT

Objective

Research is being carried out to improve the productivity and safety of underground metal mines by developing new ground control technology on backfill properties and placement, computer design utilization and bulk mining at depth.

Background

Under the 5 year Canada-Ontario Mineral Development Agreement, $3.55 million was allocated to the Productivities and Technology Program. The program has as its objective, research leading to increased mine efficiency and productivity while maintaining or improving safety in the Ontario minerals industry.

A meeting was held in January 1986, at Timmins, with senior technical representatives from the Ontario mining industry to identify research needs and priorities. At the meeting, research to develop new technology in backfill properties and placement, computers in mining and bulk mining at depth were identified as priority areas.

Several research contracts were developed and awarded to address the stated needs of the industry.

Achievements

A contract to develop computer program specifications in the Ontario mining industry has been completed by Mining Resource Engineering Limited, of Kingston, Ontario. The report is now being processed for general distribution.

Research contracts, with INCO Limited and Dome Mines Limited, to investigate the performance of dewatered tailings and the liquification potential of backfill are on schedule. Final reports are expected in mid 1987. Equipment to establish an MRL Mining Research Laboratory backfill laboratory has been purchased.

The majority of bulkheads, mouse traps and instrumentation has been installed by Denison Mines Limited for use in their contract study of the effectiveness of consolidated fill in controlling violent pillar failure. A test stope at the Kidd Creek Mine, which is being used to study the in situ properties of backfill alternatives, has been instrumented and is now being backfilled. A mine modelling contract with Inco is underway. The company is now in the process of selecting sub-contractors.

A contract with Falconbridge Limited, to monitor and model the performance of a cemented sill mat and surroundings in the tertiary stage of mining, has been extended to September 1987.

Bernie Gorski
(Technologist)

studies output from Rock Mechanics test system control panel

Fig. 5

Rand Jackson
(Physical Scientist)

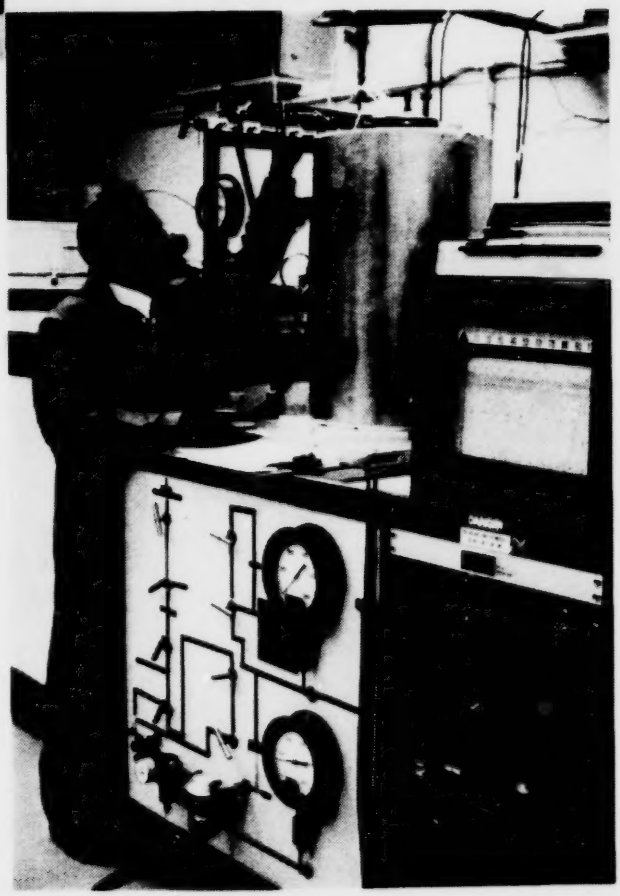
installs a sample in the high temperature, high pressure permeability apparatus

Fig. 6

Rand Jackson and Ah-Soo Wong
(Physical Scientists)

conduct stiff triaxial tests on 300,000 lb. load frame and confining pressure panel

Fig. 7



Alfred Annor (Physical Scientist)

adjusts gauges on the high temperature, high pressure permeability apparatus

Fig. 8

MINERAL RESERVES ASSESSMENT

SUB-SUB ACTIVITY: MINERAL RESERVES ASSESSMENT

URANIUM RESERVES

Objectives

A report is prepared annually on Canada's economically mineable uranium reserves and inferred resources. To meet departmental needs, the ore reserves of specified mineral deposits are determined. New ore reserve evaluation methodolgies are developed to improve the assessment of mineral reserves and related economic values.

Background

In 1974, the need for an expanded role for nuclear power in Canada was recognized. Accordingly, a policy was initiated to encourage exploration for uranium in Canada. In addition, the Uranium Resource Appraisal Group (URAG), was established, with the mandate to maintain a continuous, reliable and uniform assessment of Canadian uranium reserves, resources, and productive capability as a basis for the nuclear related aspects of the government's energy policy. In support of URAG, three departmental sub-committees were created: the Sub-committee on Reasonably Assured Resources (measured and indicated reserves); the Sub-committee on Estimated Additional Resources (inferred, prognosticated and speculative resources); and the Sub-committee on Economics of Supply and Demand. The Ore Reserves Assessment Group, (ORAG), established within the organization of the Mining Research Laboratories (MRL), is responsible for leadership of the Sub-committee on Reasonably Assured Resources and participates in the work of the other two sub-committees.

Since its inception in 1974, ORAG, on behalf of URAG, has assembled primary assaying and sampling data on relevant uranium deposits on a continuing basis. At the same time, its staff has developed required procedures for computer storage of the assembled data, as well as a variety of computer-applicable assessment methodologies for evaluation of mineral reserves and resources. ORAG produces a major internal confidential report annually, which contains the current status of Reasonably Assured reserves and Associated Inferred resources of uranium and thorium in all developed deposits in the country, regardless of whether or not these are actively producing or dormant. The report also contains the actual, or estimated projected production capabilities of these deposits.

Achievements

During 1986/87, ORAG prepared its Annual Report entitled: "Assessment of Reasonably Assured Resources of Uranium in the Major Deposits of Canada 1985", and submitted it to URAG. In addition, it assessed the Inferred Resources of uranium, associated with the Reasonably Assured resources for the use of the Regional Mineral Resource Assessment Section/Mineral Resources Division of the Geological Survey of Canada. This section is responsible for leadership of the Sub-committee on Estimated Additional Resources of uranium.

Also during 1986/87, it continued its data collecting activity of current primary assaying and sampling data from active uranium mining and development companies. The collected data were encoded into ORAG's computer data files and will be utilized in the preparation of ORAG's 1986 Annual Report, and in various other studies specific to individual uranium deposits.

In the last months of 1986/87, ORAG personnel developed an instruction handbook for computer-coding of primary sampling and assaying data on computer terminals, entitled: "A User-manual of the CDDE/1.0 Computer Program - Optimization of Drill Log Data Entry into a Computer Data Bank", (Division Report M&ET/MRL87-8(TR)).

Additionally, computer-plotted survey maps and grade-isocontour maps were prepared for two producing uranium mines in the Elliot Lake area during the fiscal year.

Mining Research Laboratories
1986
Reports Listing for CMTL

SP 86-10E	Survey of South African Seismic Systems (done for CANMET by Centre de Recherche Noranda) CANMET Scientific Authority: C.B. Graham	Dr. W. Bawden F.K. Kitzinger
SP 86-11E	Estimating preproduction and operating costs of small underground deposits (Work on this project was conducted under the auspicies of CANMET, EMR) CANMET Scientific Authority: R.W.D. Clarke	J.S. Redpath Limited
SP 86-12	Index of Mining Technology Projects 1986/Répertoire de Projets en Technologie Minière	R. Clarke P. Lacourse
SP 86-16E	Selected theoretical and practical aspects of studies made in conjunction with the joint Canada/FRG research project on coarse slurry, short distance, pipelining	L.B. Geller W.M. Gray
M&ET/MRL 86-4(INT)	Rock bolting guidelines Supplement 1 - A recommended procedure for underground support design and evaluation (First Draft)	M. Gyenge
M&ET/MRL 86-6(TR)	Progress report for the 1985/86 Canada/Manitoba MDA Project	Y. Yu S. Vongpaisal
M&ET/MRL 86-7(OP)	Experiments with slurries of coarse particles in a 250mm pipeline	L.B. Geller C.A. Shook
M&ET/MRL 86-8(INT)	The effects of pressure and temperature on the permeability and porosity of selected crystalline rock samples	A. Annor
M&ET/MRL 86-9(INT)	Documentation of TEKIMP	N. Toews A.S. Wong
M&ET/MRL 86-13(TR)	Stress determination with undercoring and pressure compensation	G. Herget F. Kapeller

1986 MRL Reports Listing (Cont'd)

TM&E/LRM 86-18(OPJ)	Automates et robots en exploitation minière évolution prévisible à court terme	N.R. Billette J. Pathak
M&ET/MRL 86-25(TR)	A multi-use load system for rock testing	B. Gorski
M&ET/MRL 86-28(INT)	Mechanical, thermomechanical and joint properties of rock samples from the Lac du Bonet Batholith Manitoba (Level II DRAFT)	A. Annor R. Jackson
M&ET/MRL 86-32(OPJ)	Changes of ground stresses with depth in the Canadian Shield	G. Herget
M&ET/MRL 86-33(INT)	Strength determinations of Prince Mine rocks	B. Gorski
M&ET/MRL 86-34(INT)	Uniaxial strength determinations of Lingan Mine rocks	B. Gorski
M&ET/MRL 86-35(INT)	Procedure used to characterize Lac du Bonnet rock joint core samples (Level II - DRAFT REPORT)	A. Annor R. Jackson
M&ET/MRL 86-38(OP)	Communicatations systems for isolated areas	S. Vongpaisal Y.L. Su L.C. Gregg J.L. Fuchs J.A. St. Pierre
M&ET/MRL 86-39(OP)	Influence of bonus, age and experience on Quebec underground accidents	N.R. Billette M. Laflamme
M&ET/MRL 86-43(TR)	Assessment of in situ coal resources	A. Füstös
M&ET/MRL 86-45(INT)	Strength determinations of Lingan Mine rocks	B. Gorski
M&ET/MRL 86-48(TR)	Anisotropic properties study of Lac du Bonnet granite specimens	R. Jackson
M&ET/MRL 86-49(INT)	Mechanical and thermomechanical properties of rock samples from the Eye Dashwa Lakes Pluton-Atikokan, Ontario (Level II - DRAFT REPORT)	A. Annor R. Jackson
TM&E/LRM 86-83(OP)	Guide d'ingénierie des piliers de surface: Objectifs et sujets traités	M. Bétournay

1986 MRL Reports Listing (Cont'd)

M&ET/MRL 86-85(INT)	Proposal for a joint federal/ provincial/industry research project to "study improved methods for the non-destructive testing of mine-shaft wire-ropes"	Prepared by: L. Geller & J. Udd J. Lazurko E.W. Mitchell L. Albert
M&ET/MRL 86-92(TR)	Waterproofing a 32mm diameter TV borehole inspection unit	G. Herget F. Kapeller
M&ET/MRL 86-95(OP)	The Niobec Mine: A case study of surface crown pillars	M. Bétournay S. Thivierge
M&ET/MRL 86-96(OPJ)	Evaluation of diesel emissions control technology at Noranda's Brunswick mining and smelting-mining division	M. Gangal D. Dainty D.L. McKinnon
M&ET/MRL 86-97(TR)	A preliminary stability assessment of C-102-23 stope of the Niobec mine under gravitational loading	Y.S. Yu S. Vongpaisal N.A. Toews A.S. Wong
M&ET/MRL 86-100(OPJ)	Mining automation activities at NRC and CANMET	L. Nenonen J. Scrimgeour J. Pathak J.E. Udd
M&ET/MRL 86-101(INT)	Sixth international congress on rock mechanics (Aug. 30-Sept. 3, 1987, Montreal, Quebec) A progress report to August 7, 1986	L.B. Geller G. Herget
TM&E/LRM 86-103(OPJ)	Impact du boni sur les accidents des mines souterraines: Analyse multidimensionnelle	N.R. Billette M. Laflamme
TM&E/LRM 86-109(OPJ)	Automatisation et systèmes experts dans les mines métalliques: quand, comment, pourquoi, jusqu'a quel point?	N.R. Billette
M&ET/MRL 86-110(INT)	Index of mining technology development database management programs: User's guide	P. Lacourse
M&ET/MRL 86-113(INT)	Meetings of the International Society for Rock Mechanics and attendance at rock stress symposium, Stockholm, 1986	G. Herget J.E. Udd

1986 MRL Reports Listing (Cont'd)

M&ET/MRL 86-116(INT)	Uniaxial strength determinations of Niobec Mine rocks	B. Gorski
M&ET/MRL 86-119(TR)	Preliminary geomechanical assessment of the Montauban Mine	M.C. Bétournay
TM&E/LRM 86-126(INT)	Rapport de visite des mines de la région de Chibougamau-Chapais dans le cadre de la collecte d'informations pour l'index sur le développement en technologie minière	N. Billette P. Lacourse
TM&E/LRM 86-127(INT)	Rapport de visite des mines de la région de L'amiante dans le cadre de la collecte d'informations pour l'index sur le développement en technologie minière	N. Billette P. Lacourse
M&ET/MRL 86-130(INT)	Estimating pre-production and operating costs of mining small deposits by underground methods. Mining industry comments at various stages of the project	R.W. Clarke
M&ET/MRL 86-131(TR)	Mining induced stresses in Saskatchewan potash	G. Herget A.D. Mackintosh
TM&E/LRM 86-132(OPJ)	Sommaire des histoires de cas de piliers de surface	M. Bétournay
TM&E/LRM 86-135(OPJ)	Les développements en équipment minier - les interventions récentes de CANMET	N.R. Billette
M&ET/MRL 86-136(OP)	An empirical approach to open stope design	R.C.T. Pakalnis H.D.S. Miller S. Vongpaisal T. Madill
M&ET/MRL 86-138(INT)	New TEX List Utility	N. Toews A.S. Wong
M&ET/MRL 86-139(J)	A design process for surface crown pillars of hard rock mines REVISION OF DIVISION REPORT M&ET/MRL 86-62 (OP)	M.C. Bétournay

1986 MRL Reports Listing (Cont'd)

M&ET/MRL 86-142(TR)	Anisotropic properties studies of Lac Du Bonnet granite specimens: Report No. 3	R. Jackson
M&ET/MRL 86-144(TR)	Sedimentary rocks of the Niobec surface crown pillars: Comparison of tensile strengths and moduli of elasticity from various strength tests	M.C. Bétournay B. Gorski M. Situm
M&ET/MRL 86-145(TR)	Stability assessment of C-102-23 stope of the Niobec Mine under tectonic stresses - Part II	Y.S. Yu S. Vongpaisal A.S. Wong N. Toews
M&ET/MRL 86-147(INT)	Some thoughts about improving the electro-magnetic non-destructive testing of mine-shaft wire-ropes by means of a joint federal/provincial/ industrial research project	L.B. Geller J.E. Udd
TM&E/LRM 86-149(INT)	Programmes pour l'édition du rapport final, répertoire de projets en technologie minière	P. Lacourse
M&ET/MRL 86-152(INT)	1986 Visit to Yellowknife	R.W.D. Clarke
M&ET/MRL 86-153(INT)	July/August 1986 Mine Site Visits	R.W.D. Clarke P. Lacourse
TM&E/LRM 86-154(TR)	Théorie générale sur le mélange des minerais	N.R. Billette
TM&E/LRM 86-157(TR)	Evolution de la manutention dans les mines à ciel ouvert: Nouvelles technologies	N. Billette
TM&E/LRM 86-159(INT)	Table utility	N. Toews D. Walsh A.S. Wong

MINE ENVIRONMENT

ELLIOT LAKE LABORATORY

Highlights

The official opening of the new Elliot Lake Laboratory took place on August 14, 1986, with the Honorable G.S. Merrithew, Minister of State for Forestry and Mines, cutting the ribbon. One hundred and seventy people were present including representatives of provincial and municipal governments, mining company executives and officials of many organizations that deal with the mining industry.

It was the culmination of many years of planning and construction, with the participation of Public Works Canada, the architects (Gugula, Smedley and Barban), and Energy, Mines and Resources Canada.

Major research programs include rockburst research and associated monitoring of microseismic and macroseismic events. Underground environmental studies cover the areas of radiation, ventilation and respirable dust. Surface environmental research is focused on reactive acid tailings. This is an Industry/CANMET/Provincial Government cooperative study on sulphide tailings.

Technology transfer is facilitated by the close contacts that are maintained with the mining industry.

MINE AND REGIONAL STABILITY

Background

New mines rarely have ground control problems, and those that do occur tend to be local in nature. However, towards the end of a mine's life the workings usually are extensive and even local instability can propagate into regional instability affecting the whole mine or a very large section of it. In recent years there have been examples where attempting to recover the last 10% of ore reserves has resulted in multiple rockbursts and/or caving which then resulted in abandonment of a section or closure of the complete mine. These regional problems are especially prevalent at depth in a high stress environment.

Objective

To evaluate pillar stability on a local and regional scale in Canadian hard rock mines; to determine the stress fields around these mines; and to evaluate parameters controlling stability.

Achievements

The stability of the hanging wall above the rockburst area at the Quirke Mine, at Elliot Lake, was evaluated. The pattern of seismic activity in the mine suggested that the hanging wall was starting to fracture or cave. An analysis of water flow into the mine indicated a sudden increase, in 1985, which continued into 1986. The water level of a beaver pond directly above the area dropped by 4m. A diamond drill was brought on site, in March 1986, and placed over an existing borehole near the centre of the area. Drilling indicated that there was lateral displacement at different depths on the original borehole and at a number of horizons there was severe water loss. All this evidence pointed to fracture of the hanging wall to surface over the rockburst area. This most likely occurred when the areal extent of the rockburst area below was about 500m diameter with the average depth below surface also being 500m. Following this fracturing process, the number and magnitude of the rockbursts underground decreased substantially.

Field stress measurements were taken at the Niobec Mine near Chicoutimi, Quebec. The mine used a blasthole stoping method in an irregular room-and-pillar pattern. Measurements were taken at depths of 260 and 305m and indicated a vertical stress consistent with the expected gravitational stress. Horizontal stresses averaged twice the vertical stress, again consistent with other stress measurements in the Canadian Shield.

Pillar stress measurements were taken at the Denison Mine, at Elliot Lake. These measured stresses were in good agreement with those estimated from empirical model.

At the Campbell Red Lake Mine additional field stress measurements were taken around orebodies of different orientation. This work is still in progress.

ROCKBURST RESEARCH

Background

Since 1982, rockburst activity has increased dramatically in Ontario mines. At present, 15 mines have experienced rockbursts. The end results have been fatalities, mine closures, layoffs and losses of ore reserves. In 1985, a major rockburst project was initiated in Ontario. The project covers five years, at a cost of $4.2 million, with tripartite funding from the Federal and Provincial Governments and the Ontario Mining Industry. Management and Technical Committees, consisting of representatives of the three parties, oversee the project. Research is in progress at mines in Red Lake, Elliot Lake, Sudbury and Kirkland Lake.

Objective

To develop new seismic equipment and monitoring techniques for studying rockbursts in hardrock mines; to carry out seismic studies at mines in Sudbury, and other Ontario locations; and to determine the causes and mechanisms of bursts and investigate methods for alleviation.

Achievements

In 1986 the major emphasis of the rockburst project was on the design and installation of new seismic networks around rockburst-prone mines. Three types of systems are being installed: seismograph, macroseismic and microseismic.

Seismograph stations are identical to those used to record earthquakes throughout Canada. Their purpose is to provide rockburst magnitudes (on an equivalent Richter Scale). An approximate location of hitherto unlocated rockbursts will also be obtained. Three seismograph stations are located in the Sudbury Basin (two already installed), connected via dedicated phone lines to Science North. Digitized signals from each station will be continuously transmitted to the Geophysics Division of Energy, Mines and Resources Canada in Ottawa.

Two seismograph stations, with low and high sensitivities, have been installed at Elliot Lake and connected via phone lines to the Elliot Lake Laboratory. Identical stations have also been ordered for Red Lake and Kirkland Lake.

Macroseismic systems are designed to capture complete seismic wave-forms for rockbursts of magnitude 0 to 3.0 using triaxial sensors. The main purpose of these systems is to evaluate the mechanisms of rockbursts using first motion, peak particle velocity, seismic energy and spectral frequency data from the wave-forms.

The first macroseismic system was designed by the Noranda Research Centre, under contract to CANMET, and has been installed above the rockburst area at Quirke Mine in Elliot Lake. The second system was designed by CANMET and will be installed around Falconbridge's Strathcona Mine. Similar systems will be installed at Campbell Red Lake Mine, INCO's Creighton Mine and Lac Minéral's Macassa Mine at Kirkland Lake.

All of these mines also operate their own microseismic monitoring systems which are primarily used for source locations in real time.

During 1986, two pillar destress blasts were monitored at the Campbell Red Lake and Macassa Mines. In both cases the crown pillar of a cut-and-fill stope in a narrow (2m wide) orebody was destressed. Microseismic systems were used to monitor seismic activity following the blasts and wave-form records were obtained from 8 channels. Stope convergence, pillar stress and blast vibration levels were also monitored. Computer models were also run to estimate stress transfer and closure. At Campbell Red Lake Mine the destress blast resulted in minimal microseismic activity, change in stress and stope convergence. However, at Macassa Mine, the destress blast was followed by significant microseismic activity and stope closure.

Basic research has been done on the accuracy of source location techniques for seismic events. Both linear and non-linear equation systems were examined and recommendations made on their suitability.

RESPIRABLE DUST/VENTILATION

Background

Dust is a significant factor affecting both the comfort and long-term health of workers in all mining operations. Dust from certain minerals can lead to lung disease. Lubricating oil mists and diesel exhaust fumes also carry noxious dust and gases. In addition, in uranium mines, dust particles can carry long-lived radionuclides into the respiratory system where radiation, mostly alpha-particles, emitted internally, may give rise to tissue damage.

There is a need to improve instrumentation, measurement techniques and computer programs to better assess and predict personal dust exposure, recognizing the well-established experimental fact that dust levels vary considerably for different mining operations. Furthermore, large spatiotemporal fluctuations in the dust level quite frequently occur within a given mining operation. The origin of respirable dust, its composition and size distribution, among other factors, must be known in order to develop effective control measures and to guide and interpret epidemiological and medical studies. This work requires developing an extensive data base through sampling in mines using improved dust instrumentation. It also requires adequate test and calibration facilities in order to determine the accuracy of dust instrumentation.

Control measure efforts centre on improving breakage and rock handling techniques to minimize dispersion of dust into the air, filtration of airborne dust, wetting techniques, as well as optimizing mine layout and ventilation. Ultimately, optimum control requires appropriate dust suppression and control methods to be built directly into mine equipment and mining procedures.

Objective

The objective is to evaluate the quality and quantity of respirable dust produced in various mining operations, to identify the major factors affecting dust production, and to develop control methods capable of reducing dust concentrations to acceptable levels.

Achievements

Instruments suitable for continuous monitoring of mineral, diesel and fibrous dust have been developed, but these are still in the prototype stage. Some of the instruments have been calibrated, but assessment of performance and applicability in mines is not yet complete. The monitors are designed to be compatible with commerically available data acquisition systems for telemetering data to surface for subsequent computer processing.

The first stage in studies of dust control was to quantify the major dust sources in hard rock mines. It has been shown that blasting, crushing, and rock handling are the major dust sources. Loading rock is the main cause of dust dispersion in the extractive area of the mine. Dust control studies using charged water spray systems, wet scrubbers, mechanical filtration systems and electrostatic precipitation in underground uranium mines and mills is at present a major dust control research project. Of special note, a study on the effect of a wet scrubber in a crusher/conveyor belt area has shown that a dramatic decrease in dust concentration and change in dust size distribution took place after the installation of the wet scrubber.

A dust test facility (DTF) has been completed and installed at the Elliot Lake Laboratory. Preliminary performance tests of the DTF have been conducted. A thorough technical evaluation of the facility will be completed during 1987. The dust test facility will be primarily used to test and calibrate dust instrumentation.

A ventilation/radiation study in a bacterial leaching stope at Denison Mines has been completed. The data obtained will be used in the future to improve stope operating conditions.

A radiation/ventilation study at Stanleigh Mine has been completed. The data will be used to verify radiation/ventilation mine models.

Suggestions for Further Work

1) Participation in combined studies with ventilation and radiation to investigate problems of practical relevance and common interest, particularly in the case of uranium mines, e.g., long-lived radioactive dust in the respirable range.
2) Development of a respirable dust/ventilation computer simulation model to better assess dust levels for personal exposure purposes.
3) Major thrust in dust control and suppression techniques including studies in rock fragmentation, wetting and rock handling and their relation to the production of dust (kind, concentration and size distribution) in mines. Also emphasis on built-in controls is strongly recommended.

4) The maintenance of adequate test techniques and standards for the purpose of calibrating and testing dust instrumentation for accurate determination of dust levels.
5) Use of air recirculation to reduce air pollutant levels in underground mines and to reduce ventilation costs.

RADIATION

Background

The radiation dose to uranium mine personnel can be minimized by limiting the time of exposure, protecting the worker (e.g., shielding), and by reducing the radiation level. Mechanical (forced) ventilation is one quite effective way of reducing radiation levels at work sites. However, there are other methods that may prove to be both effective and economical in helping to control and/or minimize radiation levels. Such methods include: 1) coating mine walls with certain chemical sealants to reduce radon (thoron) migration through the walls; 2) use of mixing fans to eliminate decay products by plate-out on the fan blades and on wall surfaces by convective air currents set up by the fan; 3) use of DC electric fields to remove decay products by electrostatic precipitation; 4) use, in certain cases, of special 'loose' filter materials with electret properties to remove decay products by mechanical trapping and electrostatic precipitation.

Furthermore, reliable experimental radiation data depend very much on the adequate performance of measuring instrumentation. Hence, reliable instrumentation and proper testing and calibration procedures of radiation instrumentation cannot be emphasized enough. In this light, the establishment of a large test facility for radon, thoron and their decay products is of great importance. Finally, the International Commission on Radiological Protection (ICRP) has recently made recommendations regarding limits of exposure to long-lived radioactive dust in relation to total dose exposure to external gamma-radiation and airborne alpha-emitters (i.e., radon and thoron daughters in the submicron and respirable range). Hence, identification and quantification of long-lived radioactive dust has become an important issue.

Objectives

The objective is to identify major sources of radiation; to identify the major factors affecting the release of radiation; to develop control methods to reduce radiation levels to acceptable personal dose exposures; and to develop and test radiation instrumentation to carry out the above studies. Another objective is the establishment of a national test facility for radon, thoron and their decay products.

Achievements

New instruments (monitors) suitable for continuous monitoring of radon and thoron gas, and their decay products, have been developed and technically evaluated under controlled laboratory conditions and under field conditions. The performance of these instruments has been very satisfactory. This instrumentation is compatible with commercially available data acquisition systems for telemetering data to surface for subsequent computer processing.

Field measurements were conducted on long-lived radioactive dust (LLRD) in the submicron and respirable ranges. The study was carried out at a crusher, and at a conveyor belt, in an Elliot Lake underground uranium mine. Further studies of LLRD were conducted after the installation of a wet scrubber in the same area to reduce and control dust emissions. The study showed that a substantial difference in size distribution and a dramatic reduction in LLRD concentration occured after the installation of the wet scrubber. The above studies also showed significant differences in the size distribution and concentration of LLRD from the above operations when compared to the LLRD generated in other mining operations.

A comprehensive study on the characterization of LLRD in a uranium mill (Saskatchewan) has been completed. Size distribution and concentration studies were conducted for the major mechanical and physico-chemical operations of the mill.

Field tests of a charged water spray system were done in an underground uranium mine to investigate its effect on radiation levels, including long-lived radioactive dust. Studies with this system are being continued.

Development of radiation/ventilation mine models suitable for steady-state and time-dependent conditions continued.

A radiation/ventilation study on bacterial leaching at Denison Mines has been completed. The results will be used to improve experimental operating conditions in the future.

A radiation/ventilation study at Stanleigh Mine has been completed. The data will be used to verify, among other things, radiation mine models and to estimate radiation data of practical interest.

A radon/thoron test facility (RTTF) for simulation studies, testing and calibration of radiation instrumentation is being installed at the Elliot Lake Laboratory. This will be the National Test Facility for radon/thoron and their decay products and it is expected to begin operation on a trial basis some time late 1987. The delay has been caused by problems with the building contractor in completing this facility.

Suggestions for Further Work

Close collaboration with respirable dust and ventilation scientists to characterize long-lived radioactive dust in uranium mines as related to mining operations, in particular, rock fragmentation.

Improvement of radiation/ventilation mine models for better assessment of radon and thoron daughter radiation levels for personal exposure determinations, development of radiation/dust/ventilation mine models and field studies for better assessment of personal exposure levels, including exposure to long-lived radioactive dust.

Major thrusts in radiation control and suppression techniques including the contribution from rock fragmentation and rock handling to the radon/thoron level and long-lived radioactive dust concentration. Major emphasis will be placed on built-in controls.

Improved tests, techniques, methods and standards for the calibration of radiation instruments.

NOISE AND VIBRATION

Background

Over ten years ago, intensive work in Canadian mines began on personal hearing protection and audiometric tests. Noise measurements have become common. The Elliot Lake Laboratory techniques and experience were transferred to Canadian mines through publications, or assistance in measurements.

Objective

To determine the magnitude and sources of environmental noise and vibration from mining operations, describe monitoring techniques and to identify applicable noise and vibration abatement techniques for maintaining the levels of these hazards within acceptable thresholds.

Achievements

No field or laboratory work was conducted in 1986. The emphasis was placed on completing various reports on the noise studies done at four Falconbridge mines (Falconbridge, Strathcona, Fraser and Lockerby) during 1984, and the report on noise measurements at four potash mines in Saskatchewan during 1985.

Several reports remain uncompleted.

Future Work

This project on noise and vibration will be discontinued at the end of the 1986-87 fiscal year.

ENVIRONMENTAL CONTROLS

ENVIRONMENTAL TECHNOLOGY

MINE/MILL WASTE MANAGEMENT

Background

The environmental problems associated with managing mine/mill waste containing metal sulphides are well recognized. Upon weathering, many metal sulphides, such as pyrite, marcasite and pyrrhotite in tailings oxidize in the presence of moisture, oxygen and iron-oxidizing bacteria - thiobacilli ferro-oxidans. The oxidation produces acidic conditions within the tailings which subsequently leaches many residual metals (and trace radionuclides in uranium tailings) from the tailings material resulting in highly acidic, high total dissolved solids, tailings porewater. With precipitation and recharge events, these oxidation reaction products can migrate from the tailings with surface run-off and as subsurface seepage to the surrounding environment, thereby affecting the natural quality of the area water system if control methods were not used. To control wind and water erosion, many inactive tailings sites have been successfully stabilized by revegetation which has greatly improved the aesthetics, and to a certain extent, the amount of water percolating through, because of increased evapotranspiration. The overall impact of revegetation on quality and quantity of effluent from reclaimed tailings area has yet to be determined.

Objective

The objective is to develop an effective technology of tailings disposal and management to minimize environmental impact. For inactive tailings piles the objective is to develop methods of tailings treatment, disposal and surface stabilization to reduce the detrimental effects of contaminant transport via surface run-off, groundwater infiltration as subsurface seepage erosion by wind and water.

Achievements

Under the Reactive Acid Tailings (RATS) program, hydrogeochemical investigations of highly reactive sulphide tailings are being carried out at the Waite Amulet tailings site in Noranda, Quebec. Preliminary geophysical investigations including seismic, electromagnetic and electrical resistivity surveys were completed in 1985. The results showed an irregular bedrock topography with a clay layer of varying thickness underneath the tailings. Within the tailings, a hardpan layer of tailings exists above the water table which roughly marks the boundary between oxidized and unoxidized zones. Continuous solid core tailings samples were obtained at nine locations for physical, mineralogical and chemical analyses. At two more locations, tailings were sampled for bacterial counts, including iron oxidizing and sulphate reducing organisms. A total of 55 piezometers were installed in and around the

tailings to monitor groundwater flow paths, tailings porewater chemistry and migration of contaminants. The pH and electrical conductance of the tailings porewater varied between 5-7.5 and 1,000 to 10,000vs, respectively. Fe, Ca, Mg, Zn and SO_4^{-2} have been the major ionic constituents of tailings porewater. Results to data have indicated that because of the reduced permeability of the clay layer, a good aquitard has developed with the result that the tailings porewater drains through the impoundment dams. Oxidation of the near neutral tailings porewater also takes place as it passes through shallow zones near the dams.

Mineralogical, physical and chemical analyses were conducted at Ottawa (MSL) and at the Elliot Lake Laboratory.

Monitoring, sample collection and analysis continued during 1986, and several new wells were drilled before winter set in.

Results of on-going work were presented at the 1986 National Symposium on Surface Mining, Hydrology, Sedimentology and Reclamation in Lexington, Kentucky. This presentation was recognized by an award for the outstanding technical paper at the Conference.

Future Work

The collaboration between the Elliot Lake Laboratory, Noranda Research Centre, Pointe Claire, P.Q., and Noranda Mines Ltd., Noranda, P.Q., will be continued.

With the cooperation of Denison Mines Ltd. and Rio Algom Mines Ltd. in Elliot Lake, studies on tailings area water budget and future close-out options will be pursued.

Mining Research Laboratories
1986
Reports Listing for Elliot Lake

SP 86-3E	1985-1986 Annual Report for the Canada-Ontario Industry Rockburst Project	C.H. Brehaut D.G.F. Hedley
SP 86-3F	Rapport Annuel 1985-1986 Du Project De Recherche Conjoint Canada-Ontario-Industrie Sur Les Coups De Toit	C.H. Brehaut D.G.F. Hedley
SP 86-4	Index of Underground-Environment Dust Reports: CANMET/Mining Research Laboratories, 1960-1985 Liste de rapports sur la poussière en milieu souterrain: CANMET/Laboratoires de recherche minière, 1960-1985	M.G. Grenier K.C. Butler
SP 86-5	Index of Rock Mechanics Research Reports: CANMET/Mining Research laboratories, 1964-1984 Répertoire des rapports de recherche sur la mécanique des roches: CANMET/ Laboratoires de recherche minière, 1964-1984	D.G.F. Hedley J.E. Udd
SP 86-14E	Design of a New Macroseismic Monitoring System	A. Makuch
SP 86-15E	Source Location Techniques Using P-Wave Arrivals	J. Niewiadomski
M&ET/MRL 86-1(OP)	Progress during the second half of 1985 in the environment projects of the CANMET minerals program	J. Bigu
M&ET/MRL 86-2(TR)	Past, present and future of dust research at the Elliot Lake Laboratory	M. Grenier J. Bigu
M&ET/MRL 86-14(INT)	Calibration of dust samplers for quartz analysis	G. Knight W. Zawadski

1986 MRL Reports Listing (Cont'd)

M&ET/MRL 86-26(TR)	Hazardous gases and substances found in underground mine air	M. Grenier
M&ET/MRL 86-30(OP)	Determination of environmental variables underground - Measurement techniques and instrumentation	S. Hardcastle M. Grenier J. Bigu
M&ET/MRL 86-40(INT)	Annual Review - Elliot Lake Laboratory	R. Tervo
M&ET/MRL 86-30(TR)	Plate-out of radon and thoron progeny on large surfaces	J. Bigu
M&ET/MRL 86-51(OP)	Characterization of respirable dust in a belt conveyor drift	M. Grenier S. Hardcastle J. Bigu
M&ET/MRL 86-57(TR)	Field and pillar stress determinations at Campbell Red Lake Mine, Ontario	B. Arjang
M&ET/MRL 86-58(TR)	Attenuation measurement of ear muffs at Falconbridge Complex: No. 5 shaft, The East Mine, and the mill and smelter, 1984	M.U. Savich J.K. Weglo
M&ET/MRL 86-59(TR)	Attenuation measurements of ear muffs at Lockerby Mine 1984	M.U. Savich J.K. Weglo
M&ET/MRL 86-60(TR)	Attenuation measurements of ear muffs at Strathcona Mine 1984	M.U. Savich J.K. Weglo
M&ET/MRL 86-61(TR)	Attenuation measurements of ear muffs at Fraser Mine 1984	M.U. Savich J.K. Weglo
M&ET/MRL 86-64(TR)	Calibration of the Pylon AB-5/AEP System, a continuous radon daughter working level monitor	J. Bigu
M&ET/MRL 86-65(TR)	Calibration of the pylon AB-5/EL and AB-5/PRD Systems, two continuous radon gas monitors	J. Bigu
M&ET/MRL 86-66(TR)	Effect of several radiation control measures for remedial purposes in a dwelling in the Elliot Lake area	J. Bigu
M&ET/MRL 86-71(OP)	Status of personal alpha-particle dosimetry in the uranium industry: A brief overview	J. Bigu

1986 MRL Reports Listing (Cont'd)

M&ET/MRL 86-72(OP)	Progress during the first half of 1986 in the environment projects of the CANMET Minerals Program	J. Bigu
M&ET/MRL 86-75(TR)	A review of the underground environment research program at the Elliot Lake Laboratory	J. Bigu
M&ET/MRL 86-88(OPJ)	Attenuation measurements of ear muffs at Falconbridge Limited, Canadian Nickel Division, Sudbury Operation, 1984	M.U. Savich J.K. Weglo
M&ET/MRL 86-89(TR)	Long-lived radioactivity associated with respirable quartz dust in hard rock underground uranium mines	J. Bigu
M&ET/MRL 86-90(OPJ)	On the plate-out radon and thoron progeny on large surfaces	J. Bigu
M&ET/MRL 86-98(OP)	Radiation control system for the reduction of radon daughter concentrations	J. Bigu
M&ET/MRL 86-99(OPJ)	Geophysical and biohydrogeochemical investigations of an inactive sulphide tailings basin, Noranda, Quebec, Canada	N.K. Davé T.P. Lim R. Siwik R. Blackport
M&ET/MRL 86-102(OP)	A portable radon/thoron dosimeter for personal and environmental monitoring	I. Thompson T.K. Nielsen J. Bigu
M&ET/MRL 86-104(TR)	Comparison of dust sampling instruments in coal and uranium ore dust clouds in a dust chamber	M.G. Grenier S. Hardcastle A. Frattini K. Butler
M&ET/MRL 86-106(J)	The effect of temporal concentration variations on active and passive monitoring of radon, thoron and their progeny	J. Bigu
M&ET/MRL 86-111(TR)	Pillar stress measurements at Denison Mine, Elliot Lake, Ontario	B. Arjang

1986 MRL Reports Listing (Cont'd)

M&ET/MRL 86-115(TR)	A simple apparatus for the determination of effective radium content of radium-bearing substances	M.G. Grenier
M&ET/MRL 86-122(TR)	Personal noise dosimetry survey of various occupational groups at four potash mines in Saskatchewan	K.C. Butler
M&ET/MRL 86-128(TR)	Evaluation of a charged water spray system for radiation control purposes in a hard rock underground uranium mine	J. Bigu A. Frattini
M&ET/MRL 86-133(TR)	Calibration of radiation instrumentation in a radon/thoron test facility of the walk-in type	J. Bigu
M&ET/MRL 86-134(TR)	Calibration of radon and radon progeny instrumentation of the active and passive type in a large radon/thoron test facility of the walk-in type	J. Bigu
M&ET/MRL 86-140(TR)	Characterization of long-lived radioactive dust in a conveyor belt drift	J. Bigu M.G. Grenier S. Hardcastle
M&ET/MRL 86-155(TR)	Condition on the hanging wall above the rockburst area at Quirke Mine	D.G.F. Hedley
M&ET/MRL 86-156(TR)	Comparison of respirable dust samplers in an underground hard rock mine	M.G. Grenier K. Butler
M&ET/MRL 86-158(TR)	Energy dependence of ultra-thin $CaSO_4$.Tm chips to radon and thoron progeny	H. Li J. Bigu
M&ET/MRL 86-161(J)	Effect of some variables on thoron progeny in artificial radioactive environments	J. Bigu

EQUIPMENT SAFETY CERTIFICATION

CANADIAN EXPLOSIVE ATMOSPHERES LABORATORY

Highlights

Equipment Safety Certification

During this fiscal year, a total of 55 new certificates were issued for equipment and materials for use in underground mines. In addition, we performed a total of 92 test series for other Canadian agencies and companies. These tests were mainly tests of equipment for use in explosive atmospheres with some gas detection testing. Most of these tests were performed for the Canadian Standards Association (69) with 6 tests conducted for the Canadian Gas Association and 17 for private Canadian companies.

During this period, the testing facilities at CEAL were completely renovated to make them safer and more efficient. Although this meant that our testing facilities were out of service for several months, the increased efficiency of the new facilities resulted in a much higher rate of production during the last half of the fiscal year. All of the certification and testing work conducted by CEAL is on a full cost recovery basis.

Our Standards activities this year included attendance at 6 International meetings and 14 Canadian meetings. This resulted in revisions to several existing standards, drafts of several proposed new standards and publication of a new standard for "Fire-Tested Conveyor Belting for Underground Mines".

EQUIPMENT SAFETY CERTIFICATION

EQUIPMENT CERTIFICATION AND TESTING
QUALITY ASSURANCE
STANDARDS DEVELOPMENT

Objectives

The main objectives for this activity are to provide a certification service for equipment and materials used in underground mines in Canada. The equipment is mainly for use in coal mines where there is a constant danger of explosion due to the presence of methane gas and coal dust. Electrical equipment and diesel powered equipment operating in this environment must be designed so that it will not become a source of ignition for the explosive atmospheres generated by the mining of coal. This normally means that it must be built to Flameproof (explosion-proof) standards. In the case of low energy electrical signalling devices, the energy available can be limited so that it is incapable of igniting the gas or dust. This technique is called intrinsic safety. In addition, gas detection devices must give accurate readings so that the gas hazard can be reliably assessed.

CEAL has built and maintains facilities for assessing and testing equipment to all of these rigid requirements. In addition, we have facilities for testing the emissions from Diesel engines so that some certifications have been awarded to non-flameproof diesels for use in non-gassy underground mines. As this is the only facility of its kind in Canada, testing is also performed for other Canadian Certifying Authorities such as Canadian Standards Association, Canadian Gas Association and Underwriters' Laboratories of Canada. Development testing is also performed for Canadian companies working in this field.

Fire is a very serious matter in an underground environment because it can foul the air and block exits from the mine. For this reason, CEAL performs testing and issues certificates for various fire-resistant materials for use in all underground mines. These materials include Conveyor Belting, Electric Cables, Hydraulic Fluids and Ventilating Duct Material.

Background

In 1950, the Provincial Ministers of Mines across Canada, at the insistence of the Provincial Inspectors of Mines, requested the Federal Government to set up a certification service for Electrical Equipment for use in underground coal mines. This was to assist the provincial inspectors in the performance of their mine inspections and to assist Canadian manufacturers to produce such equipment without having to go to a foreign laboratory for testing and certification.

The "Certification Laboratory" was set up in 1955 by Mines and Technical surveys (now EMR Canada). After a few years, this small laboratory was asked to expand their activities to include Fire-Resistant Conveyor Belting. Later, they were asked to include underground diesels, then other fire resistant materials, until today there are a total of twelve different categories for which certificates are granted.

When a new category is established, the standard of another country is normally used temporarily because of the absence of a Canadian equivalent. As we do not feel comfortable using the standard of another country or unilaterally establishing our own standard, we try to establish a Canadian Standard for the subject at the earliest possible time. These standards are normally published by a recognized Standards Writing Body (SWB) but much of the input and the research and development for these standards comes from CEAL. We have been instrumental in setting up a new Standards Steering Committee within the framework of the Canadian Standards Association for Electrical/Mechanical Mine Safety which now fills most of our needs for new standards. These standards must be "consensus" standards and, in addition, because Canada is a signatory to the GATT agreement, they must not be written in a manner that will restrain foreign trade. This has led us to participate in International standards activities.

CEAL staff serve on several committees of the International Standards Organization (ISO) and the International Electrotechnical Commission (IEC) and presently hold the Chairmanship of IEC Technical Committee 31, which is responsible for all the International Standards for Electrical Equipment for use in Explosive Atmospheres.

Achievements

During the past fiscal year, a total of 55 new certificates were issued by CEAL. This is down slightly from the previous year due to a backlog which has developed. This backlog is expected to dissappear when our staff is brought up to full strength.

A new list of Certified Equipment and Materials for use in Underground Mines was compiled and published (see report #1 in attached listing).

Testing for other Canadian agencies and companies rose to a record level of 92 projects. This was accomplished in spite of a six month renovation project of our testing facilities which virtually shut down all testing for several months. The increased efficiency of our new facilities and the dedication of our staff enabled us to complete much of the backlog of work in the last six months.

In the field of Standards writing; a new draft of the Flameproof Diesel Code was produced; a new edition of the CSA Standard for Explosion-proof electrical enclosures was published; extensive revisions to the standard for Hydraulic fluids were made; and the new CSA Standard for "Flame-tested Conveyor Belting for Underground Mines" was approved for publication. In addition, several other key standards were revised to keep abreast of new technology.

An oral presentation was given to the Winnipeg section of the Instrument Society of America on standards for electric process control for use in hazardous locations (see report #2 in the listing).

Research on testing methods for conveyor belting used in underground mines continued this year. A paper was published in which the U.K. and Canadian flame tests were compared (report #3). A year-long study of the reproducibility of

small-scale flammability tests was completed (report #4). An environmental chamber installed this year was used to carry out a study on the variation of electrical surface resistance with temperature and humidity (report #5). The surface resistance is a measure of the potential hazard posed by static electrical discharge in an atmosphere containing explosive gas mixtures. It was found that belts with PVC covers, although safe at room temperature, became progressively more unsafe as the temperature decreased. A lecture was given to the National Research Institute for Pollution and Resources in Japan on the research carried out on flammability testing at MRL during the past few years (report #6).

EXPLOSIVE ATMOSPHERES

EXPLOSIVE ATMOSPHERES

Highlights

The Dust Explosion Control Program involving the mining industries of the United States and Canada has commenced with new facilities and enlarged energy-derived funding. A new technologist is on staff and the explosibility of two materials has been determined, one on a cost-recovery basis. Other such cost-recovery studies are pending. An explosion investigation has been completed into the causes and prevention of ferro-silicon system hydrogen gas-initiated explosions at the Chromasco plant near Renfrew, Ontario.

The diesel emissions program is well into the technology transfer processes. All of the vehicles to be studied in several mines across Canada have been exhaust gas temperature "fingerprinted" to assist in choosing the appropriate filter option. Five of these vehicles located at Noranda's Brunswick Mine have been operating with untreated filters for over 500 hours of uneventful operation. The program now enters the second phase, i.e., the application of the next generation of catalyzed, more widely applicable, filtration systems.

The past year has seen much activity in the areas of toxicity criterion development, device development, environment quality measurements and technology transfer. This is indicated by the 12 papers presented and/or published in journals, as enumerated in the listing in this report.

FIRE & EXPLOSION HAZARD R&D

Gas and dust explosions occur with unwelcome regularity in a variety of mining, industrial and agricultural industries. CANMET work in this area began in the 1960s with the explosibility testing work of W.J. Montgomery in the Energy Research Laboratories. It was carried on in the Canadian Explosives Research Laboratory (CERL) of the Mining Research Laboratories (MRL). Now the objective of reducing the frequency of such explosions has been consolidated in the Canadian Explosive Atmospheres Laboratory (CEAL) of MRL.

During 1986 an extensive 4-month period of construction in the Canadian Explosive Atmospheres Laboratory resulted in new laboratory facilities for this relocated Dust Explosion Control program. Two competitions for a dust technologist position were held, the position filled, and the lab-scale Hartmann apparatus was recommissioned. This made it possible to perform a cost-recovery determination of the explosibility of corn starch (see report #1 in attached listing). Other cost-recovery investigations are pending.

Successful submissions for program approval and funding were made to the "Task II - Coal Supply Committee" of the Interdepartmental Panel on Energy Research and Development (PERD). Consequently, wheels have been set in motion to implement a USBM/CANMET Memorandum of Understanding on the subject of "Dust Explosion Control", involving the Canadian mining and related industries, universities and some Provincial inspectorates, in addition to the United States Bureau of Mines. This is expected to be formalized in September of 1987.

An unfortunate hydrogen/ferro-silicon dust explosion occurred on December 15, 1986 at the Chromasco magnesium works near Renfrew, Ontario. This explosion caused burn injuries to two workers and extensive damage to ferro-silicon circuit equipment and the building. MRL/CEAL was requested to investigate and recommendations were made, recorded and implemented (see report #2 in attached listing). In addition, an explosibility investigation of ferro-silicon material was undertaken in the laboratory using the Hartmann apparatus. The results (see report #3 in attached listing), indicated that this material was less of a hazard than coal dust, but explosive none-the-less. Consequently, care must be taken to prevent the formation of hydrogen by maintaining the ferro-silicon in a dry condition.

DIESEL EMISSIONS CONTROL

In general there have been three major objectives for these studies:

(1) the development of a comprehensive criterion (i.e., the AQI) by which to judge the toxicity of the several noxious components of diesel exhaust;
(2) the development of diesel emissions reduction devices, and
(3) the monitoring of air quality in dieselized underground workings.

These three objectives have been pursued in the framework of the first USBM/CANMET collaborative program, formalized by a 1981 Memorandum of Understanding between the two governments and including the Ontario Ministry of Labour. Unless reviewed, these collaborative aspects of this program will end in June of 1987.

During the past year the Air Quality Index (AQI) has been incorporated into the diesel standard for underground mines - CSA M424.1 - in order to permit the rational prescription of ventilation for certified power packages for use underground in Canada (see report #14 in attached listing), and to give credit where due for improvements to equipment etc. This document will be ballotted in 1987.

With respect to the development of diesel emissions reduction devices, the past year has seen the fruition of two major thrusts:

(1) the completion of the underground evaluation of the CANMET venturi scrubber on a Jarvis Clark Load-Haul-Dump (LHD) vehicle by the Michigan Technological University. The emissions reduction benefits were documented, confirming expectations and permitting commercialization efforts to begin in 1987/88. A paper to publicize this device was written for presentation to the international mining community at the XXIst International Conference of Mining Research Institutes in Beijing in 1987 (see report #MRL 87-18), and

(2) the last CANMET contract of the collaborative program with the Ontario Research Foundation (ORF) has documented the splendid performance of catalyst preparations in the reduction of the soot ignition temperature in ceramic wall-flow diesel particulate filters.

This has been accomplished with no negative performance characteristics. This excellent result widens the range of applicability of filters to cooler exhaust machines (see report #8 in the list of reports issued during the year).

This year has seen the formalization, in the form of reports, of much of the mine air quality data previously gathered involving diesel pollutant and AQI levels, relative performance of catalytic purifiers and ceramic filters, and mutagen and PNA levels (see reports #11, 12 and 13, 10, 9, respectively). It has been determined that present generation catalytic purifiers are being operated at their limit, i.e. at the AQI limit value of three in underground Canadian workings with no margin to spare. It has also been determined that employing ceramic filter units at least doubles the quality in the underground environment.

A significant contracted-out study was completed this year. Dr. Muir, of McMaster University, concluded from mutagenic data derived previously from the program, that the levels of health-impacting polynuclear aromatic hydrocarbons (PNAs) encountered in underground mines in Canada, do not appear to constitute an inordinate cancer risk in comparison to exposures of the general population. Animal studies performed elsewhere showed, however, that some tumours were induced at AQI levels equal to the proposed limit of three. When exposure was limited to the diesel gases only after soot removal, the incidence of tumours became zero. Both PNAs and soot are largely removed by filtration. Thus, the CANMET emphasis on water scrubber and filter developments to remove soot, has been proven correct.

This year also saw much effort put into the processes of technology transfer for this work. A special session of the Canadian Institute of Mining and Metallurgy (CIMM), Annual General Meeting, sponsored by three CIM divisions, was arranged to present the entire scope of this work. Two CANMET/MRL/CEAL

scientists contributed four of the six overview and review papers for CIMM Special Volume #36 entitled "Heavy-Duty Diesel Emission Control: A Review of Technology" (see paper #4, 6, 7, 9 and 17 in attached listing). In addition, 21 of the 33 papers reprinted in the collaborative volume were derived from CEAL efforts. Further, a requested contribution was made to a similar American technology transfer effort (see paper #7 in the listing), and presented to the American Mining Congress.

Finally, the first year of the joint industry/government NRC IRAP (PILP) technology transfer agreement with Engine Control Systems (ECS) of Aurora, Ontario, has been completed successfully. The company has determined the exhaust temperature characteristics of a large number of a variety of machines in mines all across Canada. This permits the determination of which type of filter option to apply to these various types of vehicles. They have already applied "bare" untreated filters to 5 machines at the Brunswick Mine in Bathurst, N.B.. These units have been operating without failure from normal usage for periods in excess of 500 hours to date. The next phase is to appropriately apply catalyzed filters (such as those described in report #8 in the listing) to the next lower exhaust temperature group of vehicles. This work is reported in report #18 in the attached listing.

During 1987, the Ontario Ministry of Labour will finance a study at ORF in order to apply the ceramic filter to the low exhaust temperature DDAD 2-stroke engine. This type of engine is found in substantial numbers in the mining communities of Elliot Lake and Timmins and will be a valuable addition to the PILP program. In addition, during 1986, ECS has developed an on-or-off-board burner/bypass filter regeneration system which will be dynamometer-tested along with the 2-stroke engine. There has been a problem with slow delivery of the ceramic elements from the manufacturer, but this seems to have been recently corrected. The program is progressing as expected.

Ken Judge
(Technologist)

operates a Dust Explosion Chamber to record explosion pressure

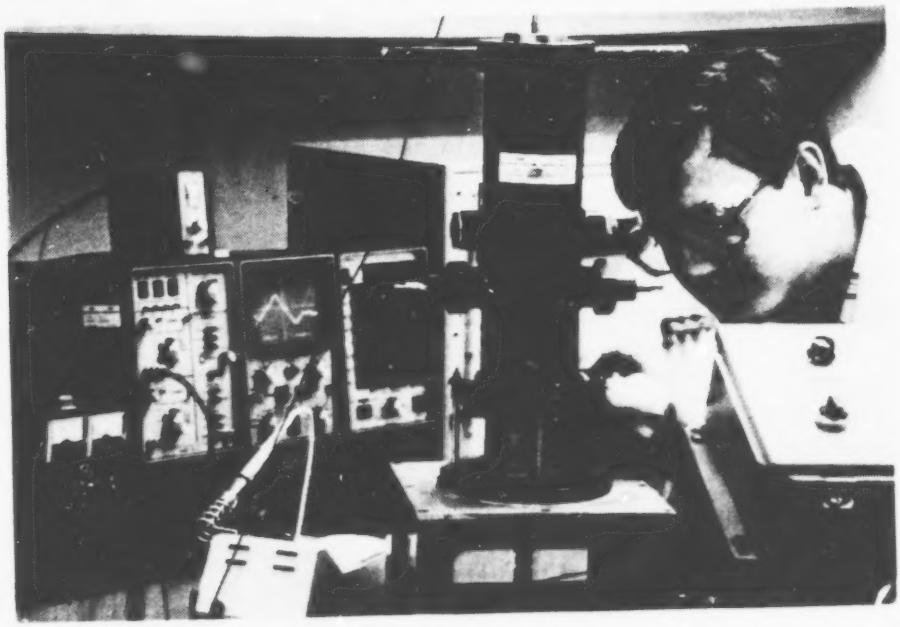


Fig. 9

Oxygen Index Apparatus tests the flamability of conveyor belts

Fig. 10

Ken Judge works on the Hartman Apparatus

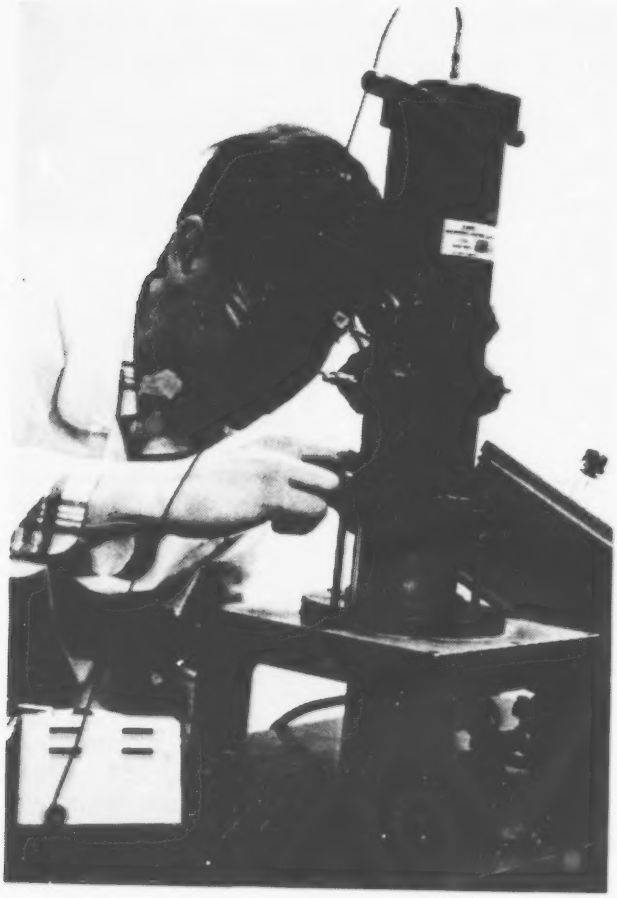


Fig. 11

Eric Dainty (Technologist adjusts controls on the Binary Gas Mixer used to check gas detectors

Fig. 12

Mining Research Laboratories
1986
Reports Listing for CEAL

M&ET/MRL 86-10(OP)	A comparison of laboratory and underground mutagen levels for treated and untreated diesel exhaust	J.P. Mogan A.J. Horton H.C. Vergeer K.C. Westaway
M&ET/MRL 86-11(OPJ)	Performance of conventional and advanced water scrubbers for controlling underground diesel exhaust emissions	J.P. Mogan A. Lawson E.D. Dainty
M&ET/MRL 86-12(CF)	Flammability testing of Fenner conveyor belting: Part II	K.J. Mintz M. Boyle E.E. Dainty
M&ET/MRL 86-15(OP)	Oral presentation to the London section of the Institute of Electrical and Electronic Engineers on hazardous locations - Feb. 7, 1986	J.A. Bossert
M&ET/MRL 86-16(J)	Diesel emission control catalysts: Friend or foe? REVISION OF DIVISION REPORT MRP/MRL 84-3(OP)	J.P. Mogan E.D. Dainty
M&ET/MRL 86-19(OPJ) E	Organization, objectives and achievements of a three government collaborative program on diesel emissions reduction research and development	E.D. Dainty E.W. Mitchell G. Schnakenberg, Jr.
TM&E/LRM 86-19(OPJ) F	Organisation, objectifs et réalisations d'un programme de recherche entrepris conjointement par trois gouvernements, sur la recherche et le développement relatifs à la réduction des émissions de diesel	E.D. Dainty D.W. Mitchell G. Schnakenberg, Jr.
M&ET/MRL 86-20(OPJ) E	A summary of underground mine investigations of ceramic diesel particulate filters and catalytic purifiers	E.D. Dainty M.K. Gangal D.H. Carlson H.C. Vergeer E.W. Mitchell
TM&E/LRM 86-20(OPJ) F	Résumé des études effectuées dans des mines souterraines sur les filtres en céramique et les épurateurs catalytiques retenant les particules rejetées par les machines diesel	E.D. Dainty M.K. Gangal D.H. Carlson H.C. Vergeer E.W. Mitchell

1986 MRL Reports Listing (Cont'd)

M&ET/MRL 86-41(TR)	List of certified equipment and materials for use in underground mines	J. Bossert G. Lobay M. Ralph
M&ET/MRL 86-42(TR)	CSA standard M424 - Iteration No. 8 flameproof diesel-powered vehicles for use in gassy underground coal mines	Compiled from Technical Committee Consultation by: E.D. Dainty & G. Lobay
M&ET/MRL 86-87(OP)	CANMET contribution to: Diesel emission control: A success story	J.P. Mogan
M&ET/MRL 86-94(TR)	Long-term reproducibility of small-scale tests used for measuring the flammability of conveyor belting	K. Mintz M. Boyle
M&ET/MRL 86-107(J)	Small-scale flame tests on fire-retardant conveyor belting	J. Szymanski K.J. Mintz
M&ET/MRL 86-121(TR)	The effect of temperature and humidity on the antistatic properties of conveyor belting	K.J. Mintz
M&ET/MRL 86-125(OPJ)	Diesel emissions reduction by ceramic filters employing catalysts or a fuel additive	E.D. Dainty A. Lawson H.C. Vergeer B. Manicom T.P. Kreuzer B.H. Engler
M&ET/MRL 86-143(J)	Monitoring and assessment of air quality in dieselized mines	M. Gangal J.P. Mogan E.D. Dainty

APPENDIX A

PUBLICATIONS

DIVISION REPORTS

ACEA = Administration of the Canada Explosives Act
M&ET = Mineral and Energy Technology
TM&E = Technologie des Minéraux et de l'Énergie
MRL = Mining Research Laboratories
LRM = Laboratoires de Recherche Minière

SPECIAL PUBLICATIONS

SP 86-3E	1985-1986 Annual Report of the Canada-Ontario Industry Rockburst Project	C.H. Brehaut D.G.F. Hedley
SP 86-3F	Rapport Annuel 1985-1986 Du Projet De Recherche Conjoint Canada-Ontario-Industrie Sur Les Coups De Toit	C.H. Brehaut D.G.F. Hedley
SP 86-4	Index of Underground-Environment Dust Reports: CANMET/Mining Research Laboratories, 1960-1985	M.G. Grenier K.C. Butler
SP 86-5	Index of Rock Mechanics Research Reports: CANMET/Mining Research Laboratories, 1964-1984	D.G.F. Hedley J.E. Udd
SP 86-6	Mining Automation: Proceedings of a workshop sponsored by CANMET/Mining Research Laboratories and the Ontario Centre for Resource Machinery Technology, Sudbury, March 12, 1986	J.E. Udd J.C. Wilson
SP 86-10E	Survey of South African Seismic Systems (done for CANMET by Centre de Recherche Noranda) CANMET Scientific Authority: C.B. Graham	Dr. W. Bawden F.K. Kitzinger
SP 86-11E	Estimating preproduction and operating costs of small underground deposits (Work on this project was conducted under the auspicies of CANMET, EMR) CANMET Scientific Authority: R.W.D. Clarke	J.S. Redpath Limited
SP 86-12	Index of Mining Technology Projects 1986/Répertoire de projets en technologie minière	R. Clarke P. Lacourse
SP 86-14E	Design of a New Macroseismic Monitoring System	A. Makuch
SP 86-15E	Source Location Techniques Using P-Wave Arrivals	J. Niewiadomski

SP 86-16E	Selected theoretical and practical aspects of studies made in conjunction with the joint Canada/FRG research on coarse slurry, short distance, pipelining	L.B. Geller W.M. Gray
SP 87-1	Mining Automation II Proceedings of the Second Workshop Sponsored by CANMET/Mining Research Laboratories, Sudbury, Ontario October 17, 1986	J.E. Udd

JOURNAL SUBMISSIONS (J)

M&ET/MRL 86-16(J)	Diesel emission control catalysts: Friend or foe? REVISION OF DIVISION REPORT MRP/MRL 84-3(OP)	J.P. Mogan E.D. Dainty
M&ET/MRL 86-22(J)	Some examples of instrumentation for stability monitoring in Canadian underground hard rock mining	J.E. Udd
ACEA/MRL 86-23(J)	Kinetic studies of thermal decomposition of tetryl using accerlerating rate calorimetry Part I. Derivation of the activation energy for decomposition	P. Lee M.H. Back
ACEA/MRL 86-24(J)	Kinetic studies of the thermal decomposition of tetryl using accelerating rate calorimetry Part II. Products and mechanism of the reaction	P. Lee M.H. Back
M&ET/MRL 86-106(J)	The effect of temporal concentration variations on active and passive monitoring of radon, thoron and their progeny	J. Bigu
M&ET/MRL 86-107(J)	Small scale flame tests on fire-retardant conveyor belting	J. Szymanski K.J. Mintz
M&ET/MRL 86-129(J)	Monitoring of stability conditions at Falconbridge's Strathcona Mine REVISION OF DIVISION REPORT M&ET/MRL 85-93(TR)	J.E. Udd S. Bharti
M&ET/MRL 86-139(J)	A design philosophy for surface crown pillars of hard rock mines REVISION OF DIVISION REPORT M&ET/MRL 86-62(OP)	M.C. Bétournay

M&ET/MRL 86-143(J)	Monitoring and assessment of air quality in dieselized mines	M. Gangal J.P. Mogan E.D. Dainty

ORAL PRESENTATIONS (OP)

M&ET/MRL 86-1(OP)	Progress during the second half of 1985 in the environment projects of the CANMET minerals program	J. Bigu
M&ET/MRL 86-7(OP)	Experiments with slurries of coarse particles in a 250mm pipeline	L.B. Geller C.A. Shook
M&ET/MRL 86-15(OP)	Oral presentation to the London section of the Institute of Electrical and Electronic Engineers on hazardous locations - Feb. 7, 1986	J.A. Bossert
M&ET/MRL 86-30(OP)	Determination of environmental variables underground - Measurement techniques and instrumentation	S. Hardcastle M. Grenier J. Bigu
M&ET/MRL 86-31(OP)	Some thoughts on minerals industry education for the 21st century	J.E. Udd
M&ET/MRL 86-36(OP)	Speech to Laurentian University students March 12, 1986	J.E. Udd
M&ET/MRL 86-38(OP)	Communications systems for isolated areas	S. Vongpaisal Y.L. Su L.C. Gregg J.L. Fuchs J.A. St. Pierre
M&ET/MRL 86-39(OP)	Influence of bonus, age and experience on Quebec underground accidents	N.R. Billette M. Laflamme
M&ET/MRL 86-51(OP)	Characterization of respirable dust in a belt conveyor drift	M. Grenier S. Hardcastle J. Bigu
M&ET/MRL 86-56(OP)	Recent developments in remote mining systems	N. Burtnyk J. Scrimgeour J.E. Udd J. Pathak
M&ET/MRL 86-62(OP)	A design process for surface crown pillars of hard rock mines	M.C. Bétournay
M&ET/MRL 86-63(OP)	Summary reports of progress on tripartite USBM/MOL/CANMET research projects, 1985-86	J.E. Udd E.D Dainty P. Mogan L. Geller

M&ET/MRL 86-71(OP)	Status of personal alpha-particle dosimetry in the uranium industry: A brief overview	J. Bigu
M&ET/MRL 86-72(OP)	Progress during the first half of 1986 in the environment projects of the CANMET Minerals Program	J. Bigu
M&ET/MRL 86-81(OP)	Monitoring and assessment of air quality in dieselized mines	M.K. Gangal J.P. Mogan E.D. Dainty
M&ET/MRL 86-87(OP)	CANMET contribution to: Diesel emission control: A success story	J.P. Mogan
ACEA/MRL 86-91(OP)	Evaluation of thermal runaway of high explosives using accelerating rate calorimetry	P. Lee R. Vandebeek K. Feng
M&ET/MRL 86-98(OP)	Radiation control systems for the reduction of radon daughter concentrations	J. Bigu
M&ET/MRL 86-102(OP)	A portable radon/thoron dosimeter for personal and environmental monitoring	I. Thompson T.K. Nielsen J. Bigu
M&ET/MRL 86-136(OP)	An empirical approach to open stope design	R.C.T. Pakalnis H.D.S. Miller S. Vongpaisal T. Madill
ACEA/MRL 86-137(OP)	Theoretical calculation of thermal decomposition of explosives from hot spot initiation	K. Feng D. Jones
ACEA/MRL 86-141(OP)	Relating explosives sensitivity laboratory results to field tests	E. Contestabile R.R. Vandebeek

ORAL PRESENTATIONS AND JOURNAL SUBMISSIONS (OPJ)

TM&E/LRM 86-5(OPJ)	La Recherche Minière à CANMET: Son Impact Industriel	J.E. Udd N.R. Billette
M&ET/MRL 86-10(OPJ)	A comparison of laboratory and underground mutagen levels for treated and untreated diesel exhaust	J.P. Mogan A.J. Horton H.C. Vergeer K.C. Westaway
M&ET/MRL 86-11(OPJ)	Performance of conventional and advanced water scrubbers for controlling underground diesel exhaust emissions	J.P. Mogan A. Lawson E.D. Dainty

TM&E/LRM 86-18(OPJ)	Automates et robots en exploitation minière évolution prévisible à court terme	N.R. Billette J. Pathak
M&ET/MRL 86-19(OPJ) (E)	Organization, objectives and achievements of a three government collaborative program on diesel emissions reduction research and development	E.D. Dainty E.W. Mitchell G. Schnakenberg, Jr.
TM&E/LRM 86-19(OPJ) (F)	Organisation, objectifs et réalisations d'un programme de recherche entrepris conjointement par trois gouvernements, sur la recherche et le développement relatifs à la réduction des émissions de diesel	E.D. Dainty E.W. Mitchell G. Schnakenberg, Jr.
M&ET/MRL 86-20(OPJ) (E)	A summary of underground mine investigations of ceramic diesel particulate filters and catalytic purifiers	E.D. Dainty M.K. Gangal D.H. Carlson H.C. Vergeer E.W. Mitchell
TM&E/LRM 86-20(OPJ) (F)	Résumé des études effectuées dans des mines souterraines sur les filtres en céramique et les épurateurs catalytiques retenant les particules rejetées par les machines diesel	E.D. Dainty M.K. Gangal D.H. Carlson H.C. Vergeer E.W. Mitchell
M&ET/MRL 86-32 (OPJ)	Changes of Ground Stresses With Depth in the Canadian Shield	G. Herget
ACEA/MRL 86-47(OPJ)	Numerical modelling of the high velocity impact sensitivity of commercial slurry and emulsion explosives	K.K. Feng R. Vandebeek A. Bauer P. Katsabanis J. Moroz D. Duncan
M&ET/MRL 86-78(OPJ)	Mechanical and thermomechanical behaviour of Lac du Bonnet granite: Some laboratory observations	A. Annor R. Jackson
M&ET/MRL 86-82(OPJ)	Microprocessor controlled down-the-hole drill for enhancing productivity and accuracy in underground hardrock bulk mining methods	J. Pathak M. Dias
TM&E/LRM 86-83(OPJ)	Guide d'ingénierie des piliers de surface: Objectifs et sujets traités	M. Bétournay
M&ET/MRL 86-88(OPJ)	Attenuation measurements of ear muffs at Falconbridge Limited, Canadian Nickel Division, Sudbury Operation, 1984	M.U. Savich J.K. Weglo

M&ET/MRL 86-90(OPJ)	On the plate-out of radon and thoron progeny on large surfaces	J. Bigu
M&ET/MRL 86-95(OPJ)	The Niobec Mine: A case study of surface crown pillars	M. Bétournay S. Thivierge
M&ET/MRL 86-96(OPJ)	Evaluation of diesel emissions control technology at Noranda's Brunswick mining and smelting - mining division	M. Gangal D. Dainty D.L. McKinnon R.A. Blanchard
M&ET/MRL 86-99(OPJ)	Geophysical and biohydrogeochemical investigations of an inactive sulphide tailings basin, Noranda, Quebec, Canada	N.K. Davé T.P. Lim R. Siwik R. Blackport
M&ET/MRL 86-100(OPJ)	Mining automation activities at NRC and CANMET	L. Nenonen J. Scrimgeour J. Pathak J.E. Udd
TM&E/LRM 86-103(OPJ)	Impact du boni sur les accidents des mines souterraines: Analyse multi-dimensionnelle	N.R. Billette M. Laflamme
TM&E/LRM 86-109(OPJ)	Automatisation et systèmes experts dans les mines métalliques: quant, comment, pourquoi, jusqu'à quel point?	N.R. Billette
TM&E/LRM 86-123(OPJ)	Historique et perspectives des piliers de surface Canadiens	J.E. Udd M.C. Bétournay
M&ET/MRL 86-125(OPJ)	Diesel emissions reduction by ceramic filters employing catalysts or a fuel additive	E.D. Dainty A. Lawson H.C. Vergeer B. Manicom T.P. Kreuzer B.H. Engler
TM&E/LRM 86-132(OPJ)	Sommaire des histoires de cas de piliers de surface	M. Bétournay
TM&E/LRM 86-135(OPJ)	Les développements en équipement minier - les interventions récentes de CANMET	N.R Billette
ACEA/MRL 86-146(OPJ)	High velocity impact sensitivity of commercial slurry and emulsion explosives	K.K. Feng R.R. Vandebeek A. Bauer P. Katsabanis J. Moroz
ACEA/MRL 86-150(OPJ)	Evaluation of propagation sensitivity of commercial explosives in large diameter holes	K. Feng R. Vandebeek A.W. Bauer A. Bauer

TECHNICAL REPORTS (TR)

M&ET/MRL 86-2(TR)	Past, present and future of dust research at the Elliot Lake Laboratory	M. Grenier J. Bigu
M&ET/MRL 86-6(TR)	Progress report for the 1985/86 Canada/Manitoba MDA Project	Y. Yu S. Vongpaisal
M&ET/MRL 86-13(TR)	Stress determination with undercoring and pressure compensation	G. Herget F. Kapeller
ACEA/MRL 86-21(TR)	Studies into the thermal stability and reactivity of ammonium nitrate Part 2: Solid state decomposition of ammonium nitrate	P. Lee K. Ketcheson R. Vandebeek
M&ET/MRL 86-25(TR)	A multi-use load system for rock testing	B. Gorski
M&ET/MRL 86-26(TR)	Hazardous gases and substances found in underground mine air	M. Grenier
ACEA/MRL 86-29(TR)	Studies into the thermal stability and reactivity of ammonium nitrate Part I: The reactivity of various metals with ammonium nitrate studied by accelerating rate calorimetry	P. Lee R. Vandebeek
M&ET/MRL 86-41(TR)	List of certified equipment and materials for use in underground mines	J. Bossert G. Lobay M. Ralph
M&ET/MRL 86-42(TR)	CSA standard M424 - Iteration No. 8 flameproof diesel-powered vehicles for use in gassy underground coal mines	Compiled from Technical Committee Consultation by E.D. Dainty & G. Lobay
M&ET/MRL 86-43(TR)	Assessment of in situ coal resources	A. Füstös
ACEA/MRL 86-44(TR)	Evaluation of exploding wire technique as a calibrated energy source for initiating explosives	E. Contestabile E. Shimoon
ACEA/MRL 86-46(TR)	CERL's facilities for determining ballistic properties of ammunition	T.R. Craig
M&ET/MRL 86-48(TR)	Anisotropic properties study of Lac du Bonnet granite specimens	R. Jackson
M&ET/MRL 86-50(TR)	Plate-out of radon and thoron progeny on large surfaces	J. Bigu

M&ET/MRL 86-53(TR) (E)	Mining Research Laboratories Annual Report 1985-1986	Compiled by Donna Imbesi (Hill)
TM&E/LRM 86-53(TR) (F)	Rapport Annuel Des Laboratoires De Recherche Minière 1985-1986	Préparé par Donna Imbesi (Hill)
M&ET/MRL 86-54(TR)	A computer program for finite element analysis of axisymmetric solids subject to arbitrary loading (VAX/VMS Version)	Y.S. Yu N.A. Toews
M&ET/MRL 86-57(TR)	Field and pillar stress determinations at Campbell Red Lake Mine, Ontario	B. Arjang
M&ET/MRL 86-58(TR)	Attenuation measurement of ear muffs at Falconbridge Complex: No. 5 shaft, The East Mine, and the mill and smelter, 1984	M.U. Savich J.K. Weglo
M&ET/MRL 86-59(TR)	Attenuation measurements of ear muffs at Lockerby Mine, 1984	M.U. Savich J.K. Weglo
M&ET/MRL 86-60(TR)	Attenuation measurements of ear muffs at Strathcona Mine, 1984	M.U. Savich J.K. Weglo
M&ET/MRL 86-61(TR)	Attenuation measurements of ear muffs at Fraser Mine, 1984	M.U. Savich J.K. Weglo
M&ET/MRL 86-64(TR)	Calibration of the Pylon AB-5/AEP System, a continuous radon daughter working level monitor	J. Bigu
M&ET/MRL 86-65(TR)	Calibration of the pylon AB-5/EL and AB-5/PRD Systems, two continuous radon gas monitors	J. Bigu
M&ET/MRL 86-66(TR)	Effect of several radiation control measures for remedial purposes in a dwelling in the Elliot Lake area	J. Bigu
M&ET/MRL 86-68(INT)	Specification Draft for Rock Bolting	M. Gyenge
ACEA/MRL 86-73(TR)	CERL's projectile impact testing facility	E. Contestabile T. Craig P. Larsen
M&ET/MRL 86-75(TR)	A review of the underground environment research program at the Elliot Lake Laboratory	J. Bigu
M&ET/MRL 86-79(TR)	Anisotropic properties study of Lac du Bonnet granite specimens: Report #2	R. Jackson

M&ET/MRL 86-89(TR)	Long-lived radioactivity associated with respirable quartz dust in hard rock underground uranium mines	J. Bigu
M&ET/MRL 86-92(TR)	Waterproofing a 32mm diameter TV borehole inspection unit	G. Herget F. Kapeller
ACEA/MRL 86-93(TR)	CERL's sporting ammunition testing facility	E. Contestabile R. Vandebeek T. Craig
M&ET/MRL 86-94(TR)	Long-term reproducibility of small-scale tests used for measuring the flammability of conveyor belting	K. Mintz M. Boyle
M&ET/MRL 86-97(TR)	A preliminary stability assessment of C-102-23 stope of the Niobec Mine under gravitational loading	Y.S. Yu S. Vongpaisal N.A. Toews A.S. Wong
M&ET/MRL 86-104(TR)	Comparison of dust sampling instruments in coal and uranium ore dust clouds in a dust chamber	M.G. Grenier S. Hardcastle A. Frattini K. Butler
ACEA/MRL 86-108(TR)	Measuring the detonation velocity of explosives	E. Contestabile T. Craig D.L. Cox E. Nagy
M&ET/MRL 86-111(TR)	Pillar stress measurements at Denison Mine, Elliot Lake, Ontario	B. Arjang
M&ET/MRL 86-112(TR)E	Mining Research Projects (except for coal) FY 1986-1987	Compiled by: D.M. Imbesi (Hill)
TM&E/LRM 86-112(TR)F	Projets de Recherche Minière (Autres que ceux qui portent sur le charbon) AF 1986-1987	Préparé par: D.M. Imbesi (Hill)
M&ET/MRL 86-115(TR)	A simple apparatus for the determination of effective radium content of radium-bearing substances	M.G. Grenier
M&ET/MRL 86-119(TR)	Preliminary geomechanical assessment of the Montauban Mine	M.C. Bétournay
M&ET/MRL 86-121(TR)	The effect of temperature and humidity on the antistatic properties of conveyor belting	K.J. Mintz
M&ET/MRL 86-122(TR)	Personal noise dosimetry survey of various occupational groups at four potash mines in Saskatchewan	K.C. Butler

M&ET/MRL 86-128(TR)	Evaluation of a charged water spray system for radiation control purposes in a hard rock underground uranium mine	J. Bigu A. Frattini
M&ET/MRL 86-131(TR)	Mining induced stresses in Saskatchewan potash	G. Herget A.D. Mackintosh
M&ET/MRL 86-133(TR)	Calibration of radiation instrumentation in a radon/thoron test facility of the walk-in type	J. Bigu
M&ET/MRL 86-134(TR)	Calibration of radon and radon progeny instrumentation of the active and passive type in a large radon/thoron test facility of the walk-in type	J. Bigu
M&ET/MRL 86-140(TR)	Characterization of long-lived radioactive dust in a conveyor belt drift	J. Bigu M.G. Grenier S. Hardcastle
M&ET/MRL 86-142(TR)	Anisotropic properties studies of Lac Du Bonnet granite specimens: Report No. 3	R. Jackson
M&ET/MRL 86-144(TR)	Sedimentary rocks of the Niobec surface crown pillars: Comparison of tensile strengths and moduli of elasticity from various strength tests	M.C. Bétournay B. Gorski M. Situm
M&ET/MRL 86-145(TR)	Stability assessment of C-102-23 stope of the Niobec Mine under tectonic stresses - Part II	Y.S. Yu S. Vongpaisal A.S. Wong N. Toews
M&ET/MRL 86-151(TR)	Explosibility tests on ferrosilicon dust	K.C. Cheng D. Cox
TM&E/LRM 86-154(TR)	Théorie générale sur le mélange des minerais	N.R. Billette
M&ET/MRL 86-155(TR)	Condition on the hanging wall above the rockburst area at Quirke Mine	D.G.F. Hedley
M&ET/MRL 86-156(TR)	Comparison of respirable dust samplers in an underground hard rock mine	M.G. Grenier K. Butler
TM&E/LRM 86-157(TR)	Evolution de la manutention dans les mines à ciel ouvert: Nouvelles technologies	N. Billette
M&ET/MRL 86-158(TR)	Energy dependence of ultra-thin $CaSO_4$.Tm chips to radon and thoron progeny	H. Li J. Bigu

M&ET/MRL 86-161(TR)	Effect of some variables on thoron progeny in artificial radioactive environments	J. Bigu

INTERNAL REPORTS (INT)

M&ET/MRL 86-4(INT)	Rock bolting guidelines Supplement 1 - A recommended procedure for underground support design and evaluation (First Draft)	M. Gyenge
M&ET/MRL 86-8(INT)	The effects of pressure and temperature on the permeability and porosity of selected crystalline rock samples	A. Annor
M&ET/MRL 86-9(INT)	Documentation of TEKIMP	N. Toews A.S. Wong
M&ET/MRL 86-14(INT)	Calibration of dust samplers for quartz analysis	G. Knight W. Zawadski
M&ET/MRL 86-28(INT)	Mechanical, thermomechanical and joint properties of rock samples from the Lac du Bonnet, Batholith, Manitoba (Level II DRAFT)	A. Annor R. Jackson
M&ET/MRL 86-33(INT)	Strength determinations of Prince Mine rocks	B. Gorski
M&ET/MRL 86-34(INT)	Uniaxial strength determinations of Lingan Mine rocks	B. Gorski
M&ET/MRL 86-35(INT)	Procedure used to characterize Lac du Bonnet rock joint core samples (Level II - DRAFT REPORT)	A. Annor R. Jackson
M&ET/MRL 86-40(INT)	Annual Review - Elliot Lake Laboratory	R. Tervo
M&ET/MRL 86-45(INT)	Strength determinations of Lingan Mine rocks	B. Gorski
M&ET/MRL 86-49(INT)	Mechanical and thermomechanical properties of rock samples from the Eye Dashwa Lakes Pluton-Atikokan, Ontario (Level II, DRAFT REPORT)	A. Annor R. Jackson
M&ET/MRL 86-52(INT)	Mechanical properties of rock samples from East Bull Lake Pluton, Ontario (Level II, DRAFT REPORT)	A. Annor R. Jackson
M&ET/MRL 86-55(INT)	Acoustic wave velocity test procedure	R. von Sacken

M&ET/MRL 86-67(INT)	Summary reports of progress on 1985/86 Mineral and Energy projects Mining Research Laboratories	J.E. Udd E.D. Dainty G.E. Larocque J. Pathak D.M. Imbesi (Hill)
M&ET/MRL 86-68(INT)	Specification Draft for Rock Bolting	M. Gyenge
M&ET/MRL 86-70(INT)	TEX macro utilities to merge address lists	N. Toews A.S. Wong
M&ET/MRL 86-74(INT)	Supporting Capacity of Rock Bolts	M. Gyenge
M&ET/MRL 86-85(INT)	Proposal for a joint federal/ provincial/industry research project to "study improved methods for the non-destructive testing of mine-shaft wire-ropes"	Prepared by: L. Geller & J. Udd J. Lazurko E.W. Mitchell L. Albert
M&ET/MRL 86-101(INT)	Sixth International Congress on Rock Mechanics (Aug. 30-Sept. 3, 1987, Montreal, Quebec) A progress report to August 7, 1986	L.B. Geller G. Herget
M&ET/MRL 86-110(INT)	Index of mining technology development database management programs: User's guide	P. Lacourse
M&ET/MRL 86-113(INT)	Meetings of the International Society for Rock Mechanics and attendance at rock stress symposium, Stockholm, 1986	G. Herget J.E. Udd
M&ET/MRL 86-116(INT)	Uniaxial strength determinations of Niobec Mine rocks	B. Gorski
M&ET/MRL 86-118(INT)	Report on a visit to the Tytyri Limestone Mine, Lohja, Finland	J.E. Udd
ACEA/MRL 86-120(INT)	Application of the Cyber 730 mainframe computer with the TI micro-computer	I.W. Reilly
TM&E/LRM 86-126(INT)	Rapport de visite des mines de la région de Chibougamau-Chapais dans le cadre de la collecte d'informations pour le répertoire de projets en technologie minière	N. Billette P. Lacourse
TM&E/LRM 86-127(INT)	Rapport de visite des mines de la région de L'amiante dans le cadre de la collecte d'informations pour l'index sur le développement en technologie minière	N. Billette P. Lacourse

M&ET/MRL 86-130(INT)	Estimating pre-production and operating costs of mining small deposits by underground methods. Mining industry comments at various stages of the project.	R.W. Clarke
M&ET/MRL 86-138(INT)	New TEX List Utility	N. Toews A.S. Wong
M&ET/MRL 86-147(INT)	Some thoughts about improving the electro-magnetic non-destructive testing of mine-shaft wire-ropes by means of a joint federal/provincial/ industrial research project	L.B. Geller J.E. Udd
TM&E/LRM 86-149(INT)	Programmes pour l'édition du rapport final, répertoire de projets en technologie minière	P. Lacourse
M&ET/MRL 86-152(INT)	1986 Visit to Yellowknife	R.W.D. Clarke
M&ET/MRL 86-153(INT)	July/August 1986 Mine Site Visits	R.W.D. Clarke P. Lacourse
M&ET/MRL 86-159(INT)	Table utility	N. Toews D. Walsh A.S. Wong

PRESENTATIONS

Annor, A. and Jackson, R. "Mechanical and thermomechanical behaviour of Lac Du Bonnet granite: Some laboratory observations"; presented at the Canadian Nuclear Society, 2nd International Conference on Radioactive Waste Management; Sept. 7-11, 1986. [Divisional Report MRL 86-78]

Bétournay, M.C. "A design process for surface crown pillars of hard rock mines"; presented at the 88th Annual General Meeting of the CIM, Montreal, Quebec, May 11-15, 1986. [Divisional Report MRL 86-62]

Bétournay, M.C. "Guide d'Ingénierie des piliers de surface : Objectifs et sujets traités"; Présentation, Colloque sur l'Ingénierie des Piliers de Surface, Val d'Or, Québec, le 10 novembre 1986. [Rapport Divisionnel MRL 86-83]

Bétournay, M.C. and Thivierge, S. "The Niobec Mine: A case study of surface crown pillars"; presented at the Surface Crown Pillar Colloquium, Val d'Or, Québec, November 10, 1986. [Divisional Report MRL 86-95]

Bétournay, M.C. "Sommaire des histoires de cas de piliers de surface"; présentation, Colloque sur l'Ingénierie des Piliers de Surface, Val d'Or, le 10 novembre 1986. [Rapport Divisionnel MRL 86-132]

Bigu, J. "Progress during the second half of 1985 in the environment projects of the CANMET Minerals Program"; presented to the joint panel on Occupational and Environmental Research for Uranium Production in Canada, Toronto, Ontario, Dec. 3-4, 1985. [Divisional Report MRL 86-1]

Bigu, J. "Status of personal alpha-particle dosimetry in the uranium industry: A brief overview"; presented to the Joint panel on Occupational and Environmental Research for Uranium Production in Canada (Personal Dosimetry Working Group) Saskatoon, Saskatchewan, May 27-28, 1986. [Divisional Report MRL 86-71]

Bigu, J. "Progress during the first half of 1986 in the environment projects of the CANMET Minerals Program"; presented to the Joint Panel on Occupational and Environmental Research for Uranium Production in Canada, May 27-28, 1986; Saskatoon, Saskatchewan. [Divisional Report MRL 86-72]

Bigu, J. "On the plate-out of radon and thoron progeny on large surfaces"; presented to the 191st National Meeting of the American Chemical Society (section: Radon and Its Decay Products: Occurrence, properties, and health effects), Apr. 13-18, 1986, New York, U.S.A. [Divisional Report MRL 86-90]

Bigu, J. "Radiation control systems for the reduction of radon daughter concentrations"; presented at the 31st Annual Meeting of the Health Physics Society, June 29-July 3, 1986, Pittsburgh, Pennsylvania, U.S.A. [Divisional Report MRL 86-98]

Billette, N.R. et Pathak J. "Automates et robots en exploitation minière : évolution prévisible à court terme"; présenté au colloque sur la recherche minérale, son impact sur la rentabilité, Québec, Qué. 18-19 février 1986. [Rapport Divisionnel MRL 86-18]

Billette, N.R. et Laflamme, M. "Impact du boni sur les accidents des mines souterraines : analyse multidimensionnelle"; présenté au colloque sur "l'analyse des données appliquée à la santé et à la sécurité du travail", 8 octobre 1986, IRSST, Montréal. [Rapport Divisionnel MRL 86-103]

Billette, N.R. "Automatisation et systèmes experts dans les mines métalliques: quand, comment, pourquoi, jusqu'à quel point?"; présenté au colloque "Le virage technologique - c'est les temps d'agir", CAO/FAO 86, Montréal, 18 septembre 1986. [Rapport Divisionnel MRL 86-109]

Billette, N.R. "Mining equipment developments - Recent involvement of CANMET"; presented at the meeting "Underground Mining Equipment ...Evolution to come", CRM/AMMQ/CANMET, Val d'Or, Quebec, Nov. 12, 1986. [Divisional Report MRL 86-135]

Bossert, J.A. "Oral presentation to the London section of the Institute of Electrical and Electronic Engineers on hazardous locations - February 7, 1986"; presented at and sponsored by the Institute of Electrical and Electronic Engineers (IEEE), London Chapter, Fanshaw College, London, Ontario, February 1986. [Divisional Report MRL 86-15]

Burtnyk, N., Scrimgeour, J., Udd, J.E. and Pathak, J. "Recent developments in remote mining systems"; presented at the Annual General Meeting, Canadian Institute of Mining and Metallurgy, Montreal, Quebec, May 11-15, 1986. [Divisional Report MRL 86-56]

Breu, F., Topp, R., Enga, B.E. and Dainty, E.D., "Application engineering of particulate control systems for underground use"; presented to the 1987 SAE International Congress and Exposition, Detroit, Mich., U.S.A. February, 1987. SAE Paper No. 870255

Contestabile, E., Vandebeek, R.R. "Relating explosives sensitivity laboratory results to field tests"; presented to the Society of Explosives Engineers at the "1987 Conference on Explosives and Blasting Technique"; Feb. 1-6, 1987, Miami, Florida, U.S.A. [Divisional Report MRL 86-141]

Dainty, E.D., Gangal, M.K. and Carlson, D.H. "A summary of underground mine investigations of ceramic diesel particulate filters and catalytic purifiers"; presented at the AMC General Meeting, Las Vegas, California, U.S.A., Oct. 7, 1986. [Divisional Report MRL 86-20]

Dainty, E.D., Mitchell, E.W. and Schnakenberg, G.W. Jr. "Organization, objectives and achievements of a three government collaborative program on diesel emissions reduction research and development"; presented to the CIM/AGM, Montreal, Québec, May 14, 1986. [Divisional Report MRL 86-19]

Dainty, E.D., Lawson, A., Vergeer, H.C., Manicom, B., Kreuzer, T.P. and Engler, B.H. "Diesel emissions reduction by ceramic filters employing catalysts or a fuel additive"; presented to the Society of Automotive Engineers International Congress, Detroit, Michigan, U.S.A., Feb. 24, 1987. [Divisional Report MRL 86-125]

Dainty, E.D., Lawson, A., Verger, H.C. Manicom, G., Kreuzer, T.P. and Engler, B.H. "Diesel emissions reduction by ceramic filters employing catalysts or a fuel additive"; presented to the 1987 SAE International Congress and Exposition; Detroit, Mich., U.S.A. Feb. 1987. [Divisional Report MRL 86-125]

Dave, N., Lim, T.P., Siwik, R. and Blackport, R. "Geophysical and biohydrogeochemical investigations of an inactive sulphide tailings basin, Noranda, Quebec, Canada"; presented at 1986 National Symposium on Surface Mining, Hydrology, Sedimentology and Reclamation, Lexington, Kentucky, 7-12 December 1986. (Presented with an award for outstanding technical paper.) [Divisional Report MRL 86-99]

Feng, K.K., Vandebeek, R.R., Bauer, A., Katsabanis, P., Moroz, J. and Duncan, D. "Numerical modelling of the high velocity impact sensitivity of commercial slurry and emulsion explosives"; presented to the International Symposium on Intense Dynamic Loading and its effects, June 3-7, 1986, Beijing, China. [Divisional Report MRL 86-47]

Feng, K.K., Vandebeek, R.R. Bauer, A.W. and Bauer, A. "Evaluation of the propagation sensitivity of small diameter blasting slurries, water gels and emulsions"; presented at the 88th Annual General Meeting of the CIM, Montreal, Quebec, May 1986. [Divisional Report MRL 85-141]

Feng, K.K., Vandebeek, R.R., Bauer, A., Katsabanis, P. and Moroz, J. "High velocity impact sensitivity of commercial slurry and emulsion explosives"; presented at the 22nd Explosives Safety Seminar, Aug. 26-28, 1986, Anaheim, California, U.S.A. [Divisional Report MRL 86-146]

Feng, K.K., Vandebeek, R.R., Bauer, A.W. and Bauer, A. "Evaluation of propagation sensitivity of commercial explosives in large diameter holes"; presented at the 13th Annual Conference on Explosives and Blasting Technique and the 3rd Mini-Symposium on Research, February 1-6, 1987, Miami, Florida, U.S.A. [Divisional Report MRL 86-150]

Gangal, M.K., Mogan, J.P. and Dainty, E.D. "Monitoring and assessment of air quality in dieselized mines"; presented at the District No. 1 Meeting of the CIM, Halifax, Nova Scotia, Nov. 20-22, 1986. [Divisional Report MRL 86-81]

Gangal, M.K., Dainty, E.D., McKinnon, D.L. and Blanchard, R.A. "Evaluation of diesel emissions control technology at Noranda's Brunswick mining and smelting - mining division"; presented at the 17th Annual Technical Session, New Brunswick branch of the CIM, Bathurst, New Brunswick, Sept. 5, 1986. [Divisional Report MRL 86-96]

Geller, L.B. and Shook, C.A. "Experiments with slurries of coarse particles in a 250mm pipeline"; presented at the 10th International Conference on the Hydraulic Transport of Solids in Pipes, Hydrotransport 10, Innsbruck, Austria, 29-31 Oct. 1986. [Divisional Report MRL 86-7]

Grenier, M., Hardcastle, S. and Bigu, J. "Characterization of respirable dust in a belt conveyor drift"; presented at the 88th Annual General Meeting of the CIM, Montreal, Quebec, 11-15 May, 1986. [Divisional Report MRL 86-51]

Hardcastle, S., Grenier, M. and Bigu, J. "Determination of environmental variables underground - measurement techniques and instrumentation"; presented to CIM (Algoma Branch), Elliot Lake, Ontario, Jan. 20, 1986. [Divisional Report MRL 86-30]

Herget, G. "Changes of ground stresses with depth in the Canadian Shield"; presented at the International Symposium on Rock Stress Measurements, Stockholm, Sweden, Sept. 1-3, 1986 [Divisional Report MRL 86-32]

Lee, P.P., Vandebeek, R.R. and Feng, K.K. "Evaluation of thermal runaway of high explosives using accelerating rate calorimetry"; presented at the 41st Annual Calorimetry Conference, Aug. 17-22, 1986 at Somerset, New Jersey, U.S.A. [Divisional Report MRL 86-91]

Mogan, J.P., Horton, A.J., Vergeer, H.C. and Westaway, K.C. "A comparison of laboratory and underground mutagen levels for treated and untreated diesel exhaust"; presented to the CIM/AGM, Montreal, Québec, May 14, 1986. [Divisional Report MRL 86-10]

Mogan, J.P., Lawson, A. and Dainty, E.D. "Performance of conventional and advanced water scrubbers for controlling underground diesel exhaust emissions"; presented to the CIM Annual General Meeting, Montreal, Québec, May 14, 1986. [Divisional Report MRL 86-11]

Mogan, J.P. "CANMET contribution to: Diesel emission control: A success story"; presented at the International Mining Show, Las Vegas, Oct. 9, 1986. [Divisional Report MRL 86-87]

Nenonen, L., Scrimgeour, J., Pathak, J. and Udd, J.E. "Mining automation activities at NRC and CANMET"; presented at the 1st Canadian symposium on automation in mining, Sudbury, Ontario, Oct. 14-16, 1986. [Divisional Report MRL 86-100]

Pathak, J. and Dias, M. "Microprocessor controlled down-the-hole drill for enhancing productivity and accuracy in underground hardrock bulk mining methods"; presented at the 8th WVU International Mining Electrotechnology Conference, Morgantown, West Virginia University, U.S.A., July 30-Aug. 1, 1986. [Divisional Report MRL 86-82]

Savich, M. and Weglo, J.K. "Attenuation measurements of ear muffs at Falconbridge Ltd., Canadian Nickel Division, Sudbury Operation, 1984"; presented at Conf. on Occupational Health for Ontario Miners, Sudbury, Ontario, November 1986. [Divisional Report MRL 86-88]

Thomson, I., Nielsen, T.K. and Bigu, J. "A portable radon/thoron dosimeter for personal and environmental monitoring"; presented at the 31st Annual Meeting of the Health Physics Society; June 29-July 3, 1986, Pittsburgh, Pennsylvania, U.S.A. [Divisional Report MRL 86-102]

Udd, J.E. et Billette, N.R. "La recherche minière à CANMET : Son impact industriel"; présenté au colloque sur la recherche minérale, son impact sur la rentabilité, Québec, Qué. 19 février 1986.
[Rapport Divisionnel MRL 86-5]

Udd, J.E., Dainty, E.D., Mogan, P. and Geller, L. "Summary reports of progress on tripartite USBM/MOL/CANMET research projects, 1985-86"; presented at the Annual USBM-CANMET Meeting Sudbury, Ontario, May 27 & 28, 1986.
[Divisional Report MRL 86-63]

Udd, J.E., et Bétournay, M.C. "Historique et perspectives des piliers de surface canadiens"; Discours d'Ouverture, Colloque sur l'ingénierie des Piliers de Surface, Val d'Or, le 10 novembre 1986.
[Rapport Divisionnel MRL 86-123]

Udd, J.E. "Some thoughts on minerals industry education for the 31st century"; prepared (as Chairman of the CIM Committee on Education); presented by the CIM to the 13th Congress of the Council of Mining and Metallurgical Institutions, Singapore, May 11-16, 1986. [Divisional Report MRL 86-31]

Udd, J.E. "Speech to Laurentian University students March 12, 1986"; presented to Laurentian University students, Mar. 12, 1986.
[Divisional Report MRL 86-36]

Vongpaisal, S., Su, Y.L., Gregg, L.C., Fuchs, J.L. and St. Pierre, J.A. "Communications systems for isolated areas in mines"; presented at the 88th Annual General Meeting of the CIM, Montreal, Quebec, May 11-15, 1986.
[Divisional Report MRL 86-38]

PAPERS PUBLISHED IN CONFERENCE PROCEEDINGS

Annor, A. and Jackson, R. "Mechanical and thermomechanical behaviour of Lac Du Bonnet granite: Some laboratory observations"; Proceedings of the 2nd Int. Conf. on Radioactive Waste Management; Winnipeg, Manitoba; Sept. 7-11, 1986; pps. 311-318. [Divisional Report MRL 86-78]

Bétournay, M.C. "Guide d'ingénierie des piliers de surface : Objectifs et sujets traités"; Colloque sur l'Ingénierie des Piliers de Surface"; le 10 novembre 1986, Val d'Or, Québec; Centre de Recherches Minérales, Ste-Foy, Québec; 1987; pps. 248-267. [Rapport Divisionnel MRL 86-83]

Bétournay, M.C. and Thivierge, S. "The Niobec Mine: A case study of surface crown pillars"; Colloque sur l'Ingénierie des Piliers de Surface"; le 10 novembre 1986; Val d'Or, Québec; Centre de Recherches Minérales, Ste-Foy, Québec; 1987; pps. 94-124. [Divisional Report MRL 86-95]

Bétournay, M.C. "Sommaire des histoires de cas de piliers de surface"; Colloque sur l'Ingénierie des Piliers de Surface"; le 10 novembre 1986; Val d'Or, Québec; Centre de Recherches Minérales, Ste-Foy, Québec; 1987; pps. 11-24. [Rapport Divisionnel MRL 86-132]

Billette, N.R. et Pathak J. "Automates et robots en exploitation minière: Evolution prévisible à court terme"; Colloque La Recherche Minérale, son impact sur la rentabilité; a l'Hôtel Loews Le Concorde, Québec; 18-19 février 1986; pps. 280-293. [Rapport Divisionnel MRL 86-18]

Billette, N.R. "Les développements en équipment minier - les interventions récentes de CANMET"; Colloque sur les équipements miniers souterrains ...Evolution à venir; le 12 novembre 1986, Val d'Or, Québec; Centre de Recherches Minérales, Ste.-Foy, Québec; 1987; pps, 95-107. [Rapport Divisionnel MRL 86-135]

Dainty, E.D., Lawson, A., Vergeer, H.C., Manicom, B., Kreuzer, T.P. and Engler, B.H. "Diesel emissions reduction by ceramic filters employing catalysts or a fuel additive"; Proceedings - Society of Automotive Engineers; SAE Special Publication 702; "Diesel particulates: An update"; pps. 57-66. [Divisional Report MRL 86-125]

Dave, N.K., Lim, T.P., Siwik, R. and Blackport, R. "Geophysical and biohydrogeochemical investigations of an inactive sulphide tailings basin, Noranda, Quebec"; National Symposium on Surface Mining, Hydrology, Sedimentology and Reclamation; 13-19; Lexington, Kentucky, December 7-12, 1986. [Divisional Report MRL 86-99]

Feng, K.K., Vandebeek, R.R., Bauer, A., Katsabanis, P., Moroz, J. and Duncan, D. "Numerical modelling of the high velocity impact sensitivity of commercial slurry and emulsion explosives"; Proceedings of the International Symposium on intense dynamic loading and its effects; June 1986. [Divisional Report MRL 86-47]

Feng, K.K., Vandebeek, R.R., Bauer, A., Katsabanis, P. and Moroz, J. "High velocity impact sensitivity of commercial slurry and emulsion explosives"; Proceedings of the 22nd Explosives Safety Seminar; Aug. 1986; pps 381-416. [Divisional Report MRL 86-146]

Gangal, M.K., Dainty, E.D., McKinnon, D.L. and Blanchard, R.A. "Evaluation of diesel emissions control technology at Noranda's Brunswick mining and smelting - mining division"; Proceedings "Facing the World Mining and Freer Trade" CIM New Brunswick Branch; session 17; Sept. 5, 1986, Bathurst, N.B.; 20 pages. [Divisional Report MRL 86-96]

Herget, G. "Changes of ground stresses with depth in the Canadian Shield"; Proceedings of the International Symposium on Rock Stress Measurements; Stockholm, Sweden; 1-3 Sept. 1986; pps. 61-68. [Divisional Report MRL 86-32]

Nenonen, L., Scrimgeour, J., Pathak, J. and Udd, J.E. "Mining automation activities at NRC and CANMET"; Proceedings "Symposium - Applications of automation in mining, present and future"; 18 pages. [Divisional Report MRL 86-100]

Pathak, J. and Dias, M. "Microprocessor controlled down-the-hole drill for enhancing productivity and accuracy in underground hardrock bulk mining methods"; Proceedings of the 8th WVU International Mining Electrotechnology Conference; Morgantown, West Virginia University, U.S.A.; July 30-Aug. 1, 1986. [Divisional Report MRL 86-82]

Udd, J.E. et Billette, N.R. "La recherche minière à CANMET : Son impact industriel"; Colloque La Recherche Minérale, son impact sur la rentabilité; à l'Hôtel Loews Le Concorde, Québec; 18 et 19 février 1986; pps. 417-435. [Rapport Divisionnel MRL 86-5]

Udd, J.E. "Some examples of instrumentation for stability monitoring in Canadian underground hard rock mining"; Proceedings of the International Symposium on Large Rock Caverns; Helsinki, Finland; 25-28 Aug. 1986; vol. 1; section C2.17; pps. 433-446. [Divisional Report MRL 86-22]

Udd, J.E. et Bétournay, M.C. "Historique et perspectives des piliers de surface Canadiens"; Colloque sur l'Ingénierie des Piliers de surface"; le 10 novembre 1986; Val d'Or, Québec; Centre de Recherches Minérales, Ste.-Foy, Québec; 1987; pps. 7-10. [Rapport Divisionnel MRL 86-123]

PAPERS PUBLISHED IN OUTSIDE JOURNALS

Bigu, J. "On the plate-out of radon and thoron progeny on large surfaces"; "Radon and its decay products: Occurrence, properties, and health effects"; ACS symposium series; American Chemical Society, P.K. Hopke, editor; Washington, D.C.; 1987; chapter 21; pps. 272-284. [Divisional Report MRL 86-90]

Dainty, E.D., Mitchell, E.W. and Schnakenberg, G.W. Jr. "Organization, objectives and achievements of a three government collaborative program on diesel emissions reduction research and development"; CIM Special Volume 36; paper no. 1; Oct. 1986; pps. 3-20. [Divisional Report MRL 86-19]

Dainty, E.D., Gangal, M.K. and Carlson, D.H. "A summary of underground mine investigations of ceramic diesel particulate filters and catalytic purifiers"; CIM Special Volume 36; paper no. 4; May 1986; pps. 54-77. [Divisional Report MRL 86-20]

Dainty, E.D., Lawson, A., Vergeer, H.C., Manicom, B., Kreuzer, T.P. and Engler, B.h. "Diesel emissions reduction by ceramic filters employing catalysts or a fuel additive"; published in Diesel particulates: An update SP-702; Special volume of the Society of Automotive Engineers; Feb. 1987; pages 57-65 SAE Paper No. 870014 [Divisional Report MRL 86-125]

Feng, K.K., Vandebeek, R.R., Bauer, A.W. and Bauer, A. "Evaluaiton of the propagation sensitivity of small diameter blasting slurries, water gels and emulsions"; CIM Report; May 1987; pps. 9-10 and 22-23. [Divisional Report MRL 85-144]

Knight, G. and Moore, E. "Comparison of respirable dust samplers for use in hard rock mines" Am. Ind. Hyg. Assoc. J. 48(4): 354-363 (1987). [Divisional Report MRL 84-78(OPJ)]

Knight, G. and Moore, E. "Comparison of dust samplers: Statistical Analysis Tecniques" Am. Ind. Hyg. Assoc. J. 48(4): 344-353 (1987). [Divisional Report MRL 84-79(OPJ)]

Knight, G., Moore E., and Smith, C.W. "Size distribution of airborne dust in Labrador Iron Mines" Am. Ind. Hyg. Assoc. J. 48(2): 150-154 (1987). [Divisional Report MRL 84-79(OPJ)]

Lee, P.P. and Back, M.H. "Kinetic studies of thermal decomposition of tetryl using accelerating rate calorimetry Part I. Derivation of the activation energy for decomposition"; Thermochimica Acta; vol. 107; 1986; pps. 1-16. [Division Report MRL 86-23]

Lee, P.P. and Back, M.H. "Kinetic studies of thermal decomposition of tetryl using accelerating rate calorimetry Part II. Products and mechanism of the reaction"; Thermochimica Acta; vol. 107; 1986; pps. 17-26. [Divisional Report MRL 86-24]

Mogan, J.P., Horton, A.J., Vergeer, H.C. and Westaway, K.C. "A comparison of laboratory and underground mutagen levels for treated and untreated diesel exhaust"; CIM Special Volume 36; paper no. 5; May 1986; pps. 78-91. [Divisional Report MRL 86-10]

Mogan, J.P., Lawson, A. and Dainty, E.D. "Performance of conventional and advanced water scrubbers for controlling underground diesel exhaust emissions"; CIM Special Volume 36; paper no. 2; May 1986; pps. 21-28 [Divisional Report MRL 86-11]

Mogan, J.P. and Dainty, E.D. "Diesel emission control catalysts: Friend or Foe?"; CIM Special Volume 36; paper no. 20: Heavy duty diesel emission control; A review of technology; May 1986; pps. 251-260. [Divisional Report MRL 86-16]

Savich, M. and Weglo, J.K. "Attenuation measurements of ear muffs at Falconbridge Ltd., Canadian Nickel Division, Sudbury Operation, 1984"; CIM Bull. 79:894: 36-49; 1986. [Divisional Report MRL 86-88]

Szymanski, J. and Mintz, K.J. "Small-scale flame tests on fire-retardant conveyor belting"; Journal of Fire Sciences; vol. 4, no. 4; Jul/Aug 1986; pps. 231-236. [Divisional Report MRL 86-107]

APPENDIX B

CONTRACTS AND RESEARCH AGREEMENTS

Contract Title	Contractor	Scientific Authority	Status
Theoretical Model for Predicting Low Velocity Impact Sensitivity Bubble Sensitized Slurry Explosion	Mining Resource Engineering	K.K. Feng	In Progress
Experimental Verification of Hi Velocity Impact Model for Slurry Explosives Projectile Impact	Mining Resource Engineering	K.K. Feng	Complete
Evaluation of Propagation Sensitivity of Commercial Explosives in 15cm Diameter Hole	Mining Resource Engineering	R.R. Vandebeek	Complete
To Carry out Field & Laboratory Testing, Field Measurements & Numerical Modelling of Excavations in Potash	Cominco	G. Herget	In Progress
Estimated Preproduction & Operating Costs of Mining Small Mineral Deposits by underground Methods (UP-R-237)	J.S. Redpath	R.W.D. Clarke	Complete
Canada/New Brunswick-Task 2: Development of a Mines Services Software System	Brunswick Mining & Smelting	N. Billette	In Progress
Development, Construction & Testing of Prototype Accessories for Automation of Down-the-Hole Drill (UP-V-42)	Vadeko International	J. Pathak	In Progress
Determination of the Viability of Cavitating Hydro Impact (UP-T-223)	Teledyne Canada	J. Pathak	Complete
Computer Blast Design Program Evaluation for Large Diameter Blasthole Stopes Underground	Mining Resource Engineering	J. Pathak	Complete
Design & Development of a Blasthole Depth Measurement Test Set	Davis Engineering Limited	J. Pathak	In Progress

Contract Title	Contractor	Scientific Authority	Status
New Brunswick MDA - Use of Backfill in New Brunswick Potash Mines	Denison Potacan Potash Company	G. Herget	In Progress
Identification of Input Parameters for Numerical Modelling of Potash Strata at IMC (UP-I-192)	Int. Minerals & Chemical Corp.	G. Herget	In Progress
Regional Subsidence Related to Potash Mining	Central Canada Potash	S. Vongpaisal	In Progress
Research on Microseismic Technology	Potash Corp. of Saskatchewan	D.G.F. Hedley	In Progress
Sampling, Field Testing and Modelling of a Surface Crown Pillar, Les Mines Selbaie, Quebec	C. Mirz Engineering	M. Betournay	In Progress
Development of a State-of-the-Art Microseismic Monitoring System (UP-N-204)	Noranda	D.G. Hedley	In Progress
Ontario MDA, Part I: In Situ Determination of Dewatered Tailings Fill Properties in Ontario Mines	Dome Mines Limited	A. Annor	In Progress
Ontario MDA, Part II: In Situ Determination of Dewatered Tailings Fill Properties in Ontario Mines	INCO Limited	A. Annor	In Progress
Ontario MDA, Task 2: In Situ Monitoring & Computer Modelling of a Cemented Sill Mat & Confines During Tertiary Stage Pillar Recovery	Falcombridge Limited	A. Annor	In Progress
Ontario MDA, Task 5: Computer Programs Specifications for Ontario Mining Industry	Mining Resource Engineering	R.F. Boyle	Complete
Ontario MDA, Task /: Use of Consolidated Fills for Controlling Violent Pillar Failure in Ontario Mines	Denison Mines Limited	D. Hedley	In Progress

Contract Title	Contractor	Scientific Authority	Status
Ontario MDA, Task 5: In Situ Properties of Backfill Alternatives in Ontario Mines	Falconbridge Limited	A. Annor	In Progress
Ontario MDA: Simulation of Bulk Mining at Depth with Backfill in Ontario Mines	INCO Limited	Y.S. Yu	In Progress
Ontario MDA, Task 7, Part III: Liquefaction of Potential of Dense Backfill	Dome Mines Limited	A. Annor	In Progress
Surface Crown Pillar Study: Phase II - Case Studies	Group-Conseil Roche Ltee	M. Bétournay	Complete
Georoc: Technology Transfer Seminars for the Potash Industry	Re/Spec Limited	Y.S. Yu	Complete
New Brunswick MDA - Task 1: Blast Design Optimization and Control	TO TENDER	R.W. Clarke	
Manitoba MDA, Task 2: Ground Stability Evaluation with Reference to Echelon Lensed Orebody	Sherritt Gordon Mines	S. Vongpaisal	In Progress
Manitoba MDA, Task 3: Communication System for Isolated Areas in Mines	Sherritt Gordon Mines	S. Vongpaisal	In Progress
Manitoba MDA, Task 4: Geomechanical Data Base for Ground Control in Deep Mines	INCO Limited	Y.S. Yu	In Progress
Manitoba MDA, Task 1: Develop Vertical Block Method Design Guidelines for Steeply Dipping Orebody Techniques	INCO Limited	Y.S. Yu	In Progress
Manitoba MDA, Part III, Task 5: Optimization of Blast Design for Blasthole Mining Operators	INCO Limited	J. Pathak	In Progress
Manitoba MDA, Task 6: Delayed Backfill Consolidation	Hudson Bay Mining & Smelting	A. Annor	In Progress

Contract Title	Contractor	Scientific Authority	Status
The Development of a New Semiconductor Alpha Portable Detection System (UP-T-234)	Thompson & Neilson	J. Bigu	Complete
F.E./Modified Personal Alpha Dosimeter	Atomic Energy Control Board	J. Bigu	
Determination of the PAH Partition Ratio & Nature of Mutagens Generated by Catalytic Purifiers	Laurentian University	P. Mogan	Complete
Examination of Impact of Polynuclear Aromatic Hydrocarbon Explosion in Underground Mines	McMaster University	P. Mogan	Complete
Examination of the 100% Methanol or Pilot Diesel Methanol Engine as a Power Source for Underground Mines	INCO Limited	D. Dainty	Complete
Development of Wire Mesh Particulate Oxidizer Traps Using Full Additives (UP-E-183)	Engine Control Systems	D. Dainty	Complete
Compilation of Systems Development & Adaptation Phase of CANMET Diesel Emissions Reduction Program - Part III	Ontario Research Foundation	D. Dainty	Complete
Determination of Turbulence Effects on the Severity of Dust-Air Explosions	McGill University	K.J. Mintz	Complete
Software Package for Radon/ Thoron Test Facility Control	Real Time Systems Inc.	J. Bigu	Complete
Ecological Engineering	INCO Limited	N. Dave	Complete
A Comparative Study of 3 Methods of Reducing Acid Generation and Metals Release from Waste Rock	Falconbridge Limited	N. Dave	Complete

Contract Title	Contractor	Scientific Authority	Status
Reclamation of Acid Generation Tailings Using Float and Phosphogrypsum at Cominco	Cominco Limited	N. Dave	Complete
Hydrogeochemical Investigation of Reactive Sulphide Tailings at the Waite-Amulet Tailings Site, Noranda, Quebec - Phase II	Noranda Incorporated	N. Dave	Complete
Development of Wire Mesh Particulate Oxidizer Traps Using Fuel Additives	Engine Control Systems Limited	E.D. Dainty	Complete

APPENDIX C

REPRESENTATION ON TECHNICAL COMMITTEES

INTERNATIONAL

CANADIAN SUBCOMMITTEE OF THE INTERNATIONAL ELECTROTECHNICAL COMMISSION, TECHNICAL COMMITTEE 31

Electrical Apparatus for Explosive Atmospheres (chairman)	J.A. Bossert
Subcommittee 31G (member)	G. Lobay
Subcommittee 31H (member)	K.J. Mintz

INTERNATIONAL ELECTROTECHNICAL COMMISSION
SUBCOMMITTEE 31A

Flameproof Enclosures (chairman)	J.A. Bossert

INTERNATIONAL SOCIETY FOR ROCK MECHANICS (ISRM)

Council (Canadian Member)	J.E. Udd
Commission on Case Histories	D.G.F. Hedley
Commission on Fracture Toughness Testing of Rock	G. Swan
Committee on 1987 ISRM Congress, Montreal (General Chairman)	G. Herget

INTERNATIONAL STANDARDS ORGANIZATION
CANADIAN ADVISORY COMMITTEE

Committee on Certification - CAOCO (member)	J.A. Bossert
Technical Committee 41/Subcommittee 3, Conveyor Belting (member)	K.J. Mintz
Technical Committee 146 - Air Quality and Working Groups, SiO_2 and Inorganic Fibres (member)	G. Knight

INTERNATIONAL TUNNELLING ASSOCIATION

Tunnelling Association of Canada (member)	J.E. Udd

ORGANIZATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT (OECD)

International Group of Experts on Unstable Substances (IGUS) (national representative)	R.R. Vandebeek
IGUS - Ammonium Nitrate Working Group (co-leader)	R.R. Vandebeek
NEA International Intercalibration and intercomparison Program for Radon, Thoron and their Daughters (member)	J. Bigu

UNITED NATIONS

Group of Experts on Explosives (delegate)	R.R. Vandebeek

UNITED STATES OF AMERICA

INSTRUMENT SOCIETY OF AMERICA

Committee SP 12 Instruments for Use in Hazardous Locations (member) ..... J.A. Bossert

COLLABORATIVE PLANNING COMMITTEE FOR DIESEL EMISSION REDUCTION R & D
(CANMET representative) ..... E.D. Dainty

CANADA - FEDERAL

CANADIAN GOVERNMENT SPECIFICATIONS BOARD (CGSB)

Diesel Fuel panel of the CGSB Subcommittee on Middle Distillates (member) ..... J.P. Mogan

ENERGY, MINES AND RESOURCES CANADA (EMR)

Canada-Ontario-Industry Rockburst Project
Project Management Committee (member) ..... J.E. Udd
Project Technical Committee (chairperson) ..... D.G.F. Hedley

Committee on Radioactive Waste Containment (member) ..... G.E. Larocque

Long-term Management of Reactive Acid Tailings Sulphides
Steering Committee - (member) ..... J.E. Udd
Technical Working Group - (member) ..... R. Tervo

Occupational and Environmental Research for Uranium Production, Joint Panel (secretary) ..... R. Tervo
(member) ..... J. Bigu

Uranium Resource Appraisal Group: Subcommittee on Reasonably Assured Resources of Uranium (chairman) ..... A. Füstös

Uranium Resource Appraisal Group: Subcommittee on Estimated Additional Resrouces of Uranium (member) ..... A. Füstös

Uranium Resource Appraisal Group: Subcommittee on Econimics of Supply and Demand for Uranium (member) ..... A. Füstös

Uranium Resource Appraisal Group (member) ..... A. Füstös

TRANSPORT CANADA
Technical Committee on Dangerous Goods (member) ..... R.R. Vandebeek

CANADA - OTHER

CANADIAN GAS ASSOCIATION

Gas Fired Appliances for Hazardous Locations, No. CGA 2.25 (member) ..... G. Lobay

CANADIAN GEOTECHNICAL SOCIETY

Ottawa Geotechnical Group (executive member) ..... M. Bétournay

Subcommittee on Tunnelling (member) ..... M. Gyenge

CANADIAN GEOTECHNICAL SOCIETY

Ottawa Geotechnical Group (executive member) ..... M. Bétournay

Subcommittee on Tunnelling (member) ..... M. Gyenge

CANADIAN INSTITUTE OF MINING AND METALLURGY (CIM)

Ad-Hoc Committee on Mining and Mineral Processing Research (member) ..... J.E. Udd
(member) ..... N. Billette

Algoma Branch (laboratory representative) ..... B. Arjang

Ottawa Branch (executive committee member) ..... D. Walsh

Committee on Education for the Mineral Industry (chairman)... J.E. Udd
(member) .... N. Billette

Rock Mechanics and Strata Control Committee (vice chairman).. J.E. Udd

Subcommittee on Backfill (member) ..... G. Swan

Subcommittee on Rockbursts (vice chairman) ..... C.B. Graham

CANADIAN ROCK MECHANICS ASSOCIATION - RMSCC

Subcommittee on Non-Explosive Breakage Methods (member) ..... M. Gyenge

Subcomitte on Monitoring (member) ..... G. Herget

Subcommittee on Soft Rock (member) ..... G. Herget

CANADIAN STANDARDS ASSOCIATION

Standards Steering Committee on Electrical and Mechanical Mines Safety (vice-chairman) ..... J.A. Bossert

Technical Committee for "Flameproof Diesel-Powered Vehicles for Use in Gassy Underground Mines" M424 (chairman) ..... E.D. Dainty

Technical Committee on Accoustics and Noise Control (Construction & Mining Machines - Task Force on Occupational Noise) (member) ..... M. Savich

Technical Committee on Fire Resistant Conveyor Belting, No. M4.22 (member) ..... K.J. Mintz

Technical Committee on Fire Resistant hydraulic Fluids, No. M4.23 (member) ..... K.J. Mintz

CANADIAN STANDARDS ASSOCIATION
CANADIAN ELECTRICAL CODE, PART I

Steering Committee (member) ..... J.A. Bossert

Subcommittee on Section 18 (Chairman) ..... J.A. Bossert

CANADIAN ELECTRICAL CODE, PART II

Subcommittee on CSA Standard C22.2, No. 30: Explosion Proof Enclosures for Use in Class I, Groups, A,B,C and D Hazardous Locations (member) ..... J.A. Bossert

Subcommittee on CSA Standard C22.2, No. 137: Luminars for Hazardous Locations (member) ..... G. Lobay

Subcommittee on CSA Standard C22.2, No. 152: Combustible Gas Detection Equipment (member) ..... G. Lobay

Subcommittee on CSA Standard C22.2, No. 157: Intrinsically Safe and Non-Incendive Equipment for Use in Hazardous Locations (vice-chairman) ..... G. Lobay

Subcommittee on CSA Standard C22.2, No. 159: Plugs and Receptacles for Hazardous Locations (member) ..... G. Lobay

Subcommittee on CSA Standard C22.2, No. 174: Cables to Used in Hazardous Locations (member) ..... G. Lobay

CANADIAN ELECTRICAL CODE, PART V

Committee on CSA Standard C22.5 Use of Electricity in Mines (member) ..... G. Lobay

CANADIAN URANIUM PRODUCERS METALLURGICAL COMMITTEE (members) ..... N..K. Davé
T.P. Lim

SAULT COLLEGE, ELLIOT LAKE

Advisory Committee for the Ventilation Technician Option of the Mechanical Technology Course (members) ..... S. Hardcastle
R. Tervo

CAMBRIAN COLLEGE, SUDBURY

Advisory Council for Mining Ciriculum (member) ..... C.B. Graham

INOTITAT DE RECHERCHE EN SANTE ET SECURITE DU TRAVAIL

Comité des sciences naturelles et génie ..... N. Billette

APPENDIX D

CONTACTS, MEETINGS, FIELD TRIPS

AND JOINT CONSULTATIONS

INDUSTRY

Atlas Copco Canada, Dorval, Quebec
Atomic Energy of Canada Limited
Atlas Copco, Montreal, Quebec
Aston Pyrotechnics Canada limited, Guelph, Ontario
Armstrong Monitors Corporation, Nepean, Ontario
Appleton electric Limited, Cambridge, Ontario
Astro Canada, Guelph, Ontario
Atomic Energy Control Board
Brunswick Mine, Bathurst, New Brunswick
Beaver Construction, Montreal, Quebec
Breton Engineered Projects, Sydney, Nova Scotia
Black Box Canada incorporated, Norval, Ontario
Boart Canada, Mississauga, Ontario
Brunswick Mining and Smelting, New Brunswick
Canada Wire and Cable Limited
Canam Resource Parts, Edmonton, Alberta
CANTERRA Engineering Limited, Calgary, Alberta
Confédération des Syndicats Nationaux, Montreal, Quebec.
Cube Systems, Ottawa, Ontario
Cyanamid Canada, Niagara Falls, Ontario
Crothers Equipment, Toronto, Ontario
Chromasco, Haley Station, Ontario
Cement Canada Lafarge, St. Constant, Quebec
Computing Devices Canada Limited, Nepean, Ontario
Cogena (Canada) Limited
Cluff Mining Company, Saskatoon, Saskatchewan
CCH Capital Communication Limited, Ottawa, Ontario
Degussa Corporation, Burlington, Ontario
Denison Mines Limited
Denison Potacan Potash Company, Sussex, New Brunswick
Detour Lake Mine
Drill Systems Limited, Fort McMurray, Ontario
Dupont Canada
Dome Mines
Doyle Corporation, Kanata, Ontario
Dynatek Mining
Engine Control Systems, Aurora, Ontario
E. J. Faraci & Associates Limited, Winnipeg, Manitoba
Esso Petroleum Canada
Fiberglass Canada, Sarnia, Ontario
Falconbridge Limited
General Motors of Canada
Golder Associates, Calgary, Alberta
Genetian Construction Limited, Montreal, Quebec

Industry (cont'd)

Heath and Sherwood, Toronto, Ontario
Hands Fireworks Incorporated, Edwardburgh, Ontario
ITT Barton Manufacturing Limited
Inco Mines Limited, Thompson, Manitoba
Instantel, Kanata, Ontario
Interact Limited, Victoria, B.C.
International Corona, Toronto, Ontario
Imperial Toy Canada Limited, Mississauga, Ontario
J.S. Redpath Limited
KVA Electronics, Toronto, Ontario
Kidd Creek mines, Timmins, Ontario
Lac Minerals - Macassa Division, Kirkland Lake, Ontario
Limpact Industries Limited, Cobourg, Ontario
MSA Canada Limited
Machinery & Equipment Manufacturers Association, Ottawa, Ontario
Manitoba Mining Association
Martin McCubbin Associates
Minesco Limited, Kirkland, Quebec
Mining Resource Engineering Limited, Kingston, Ontario
Muscocho Exploration, Montauban, Quebec
Montauban Mine, Quebec
Niobec Mine, Chicoutimi, Quebec
Noranda Mines Limited
Pan-Canadian Petroleum Limited, Calgary, Alberta
Petro Canada
Philips Cables Limited, Brockville, Ontario
Pirelli Cables Limited, St. Jean, Quebec
Prospectors & Developers Association, Toronto, Ontario
Potash Company of America, Saskatoon, Saskatchewan
Price Waterhouse, Toronto, Ontario
Pyroban Corporation, Aurora, Ontario
Pyrolysis Systems Limited, Kingston, Ontario
Rio Algom Limited
Rosco and Postole, Toronto, Ontario
Robertson Nickerson Limited
S.M. Consulting, Sherbrooke, Quebec
Safety Supply Canada, Toronto, Ontario
Service de Technologie Minére
Shaw - Almex Industries
Sherritt Gordon Mines Limited
Siemens Electric Limited, Pointe Clair, Quebec
Sifto Salt, Goderich
SPAR Aerospace
Steel Company of Canada, Nanticoke, Ontario

Thyssen Mining, Regina, Saskatchewan
Total Erickson Resources, Vancouver, B.C.
Thomson and Neilson
Vadeko International, Mississauga, Ontario
Wajax Industries, Edmonton, Alberta
Weir-Jones Consulting, Vancouver, B.C.
Westech Industrial Limited

INTERNATIONAL

Atomic Energy Licensing Board, Malaysia
Buffalo Weaving and Belting, Buffalo, N.Y.
Chevron Incorporated, New Orleans, Louisiana
Croda Limited, U.K.
Dano International Services, New York, U.S. A.
Department of Health and Safety, Morroco
Detector Electronics Corporation, Minneapolis, Minnestoa
Deutz Engineering, Atlanta, Georgia
Dosco Overseas Engineering Company, Nottinghamshire, U.K.
ERA Technology, Leatherhead, England
Eimco/Jarvis Clark, Utah, U.S.A.
Engenharia, S.A., Sao Paulo, Brazil
Explosive Ordance Disposal Technical Information Centre, England
J.J. Fenner Limited, U.K.
Factory Mutual Research, Norwood, Massachusets
Government of India
General Monitors, Costa Nesa, California
Impro Corporation, Virginia, U.S.A.
Instituto Superiore de Sanita, Rome, Italy
Mineral Industries Computing Limited, U.K.
NIOSH, Cincinnati, Ohio
NIOSH, U.S.A.
National Atomic Energy Commission, Argentina
Nuclear Assurance Company, Grand Junction, Colorado
Petrobas Mining, Aracaju, Brazil
Odebrecht Construction, Aracaju, Brazil
Odebrecht-Harrison, Salvador, Brazil
Oxygen Therapy Institute, Michigan, U.S.A.
Round-Up Powder Company, Montana, U.S.A.
S. Agumber, Croda, U.K.
Scandura Mining Products
Scharf Company, Pittsburgh, Pennsylvania, U.S.A.
Singapore Institute of Standards, Singapore
South African Chamber of Mines
Telesis, Providence, Rhode Island
Turkish Atomic Energy Centre Laboratory
Tuula Kyraes, Luleaa, Sweden
United States Bureau of Mines
Westfalia - Lunen Company, West Germany

FEDERAL

Canadian Standards Association
Department of National Defence
Departmen$of Public Works
Department of Regional Industrial Expansion
Energy, Mines and Resources - Coal Division
Labour Canada
North West Territories Chamber of Mines
Royal Canadian Mounted Police
Transport Canada

PROVINCIAL

Energy, Mines and Resources - Saskatoon, Saskatchewan
Government of Quebec (Quebec Metal Mining Association)
Mines Accidental Prevention Association of Ontario
Mines Inspection Branch - British Columbia
Ministry of Mines, Energy & Petroleum Resources of British Columbia
Ministry of Northern Development & Mines
New Brunswick Department of Minerals and Energy
Ontario Centre of Resource Machinery Technology
Ontario Department of Northern Affairs
Ontario Hydro
Ontario Ministry of Labour
Ontario Research Foundation
Regional Industrial Expansion - Halifax, Nova Scotia

UNIVERSITIES

Cambrian College
Columbia University, New York
Ecole Polytechnique
Fanshaw College
Haileybury School of Mines - Northern College
Laurentian University
Laval University
Lisgar Collegiate
McGill University
Michigan Technological University
Pen State University
University of Alberta
University of Kyoto
University of Toronto
University of Waterloo

APPENDIX E

COST RECOVERY

COST RECOVERY

Company	Number of samples/tests	Amount invoiced
ABC Manufacturers of Canada	22	$ 3,802.00
Appleton Electric Ltd.	6	1,471.00
Cable Belt Ltd. (UK)	3	810.00
Conspec Controls Inc.	2	368.00
Canada Wire & Cable	10	2,415.00
Canadian Standards Association	146	33,124.00
Foxboro Canada Inc.	5	1,072.00
Canadian Gas Association	1	552.00
Dometech Company Ltd.	1	107.00
Drill Systems	2	369.00
Electronics Test Centre	4	857.00
Brush Electrical Machines (UK)	1	184.00
General Monitors Inc. (USA)	1	918.00
Dow Chemical Canada	1	122.00
British Jeffrey Diamond (UK)	1	185.00
Detector Electronic Corp. (USA)	2	398.00
Applied Physics Ltd. (UK)	1	184.00
Computalog Gearhart Ltd.	2	369.00
Fiberglass Reinforced Plastics	1	184.00
Fiberglass Canada Ltd.	1	700.00
GEC Witton Kramer (UK)	1	184.00
MEI Mining Equipment Ltd. (UK)	7	1,291.00
Oak Supply Inc.	3	665.00
Reliance Elect. Ltd. (USA)	2	551.00
BRUEST Industries Inc. (USA)	2	369.00
Joy Machinery Co.	5	2,314.00
Status Engineering Ltd. (UK)	8	1,476.00
Phillips Cables Ltd.	23	5,892.00
Rel-Tek Corp'n Ltd. (U.S.A.)	4	738.00
Rocktest Ltd.	1	184.00
St. Lawrence Starch Co. Ltd.	2	2,700.00
Shaeffer Manufacturing Co. (USA)	2	490.00
Shawflex Inc.	5	1,377.00
Croda Application Chemical Ltd. (UK)	3	1,195.00
Victor Products PLC (UK)	1	184.00
Westfalia Lunen (West Germany)	1	184.00
Sub-Total		$67,985.00

Cost Recovery (cont'd) - X-Ray Analysis Elliot Lake Laboratory

Company	Number of samples/tests	Amount invoiced
Dome Mines Ltd.	27	$ 759.00
ERCO (Tenneco Canada Ltd.)	6	102.00
Giant Yellowknife Mines	61	1,037.00
Gov't of Newfoundland and Labrador	48	816.00
Hudson Bay Mining & Smelting	19	323.00
Indusim Ltd.	34	578.00
Kidd Creek Mines	25	425.00
La Compagnie Miniere	27	459.00
Noranda Mines	90	1,530.00
Noranda Research Centre	25	425.00
Pamour Porcupine Mines Ltd.	46	782.00
Renabie Mines (1981) Ltd.	6	102.00
University of Toronto	24	408.00
EIMCO/course	Travel	60.05
Drill Systems Ltd.	Travel	951.20
Macassa Mines	Travel	505.20
Standards Council of Canada	Travel	1,049.00
Atomic Energy Control Board	Travel	3,587.59
Cyanamid Canada Inc.	Travel	293.11
University - Industry Program NSERCC	Travel 10 Trips	395.25
Special Cost Recovery Items - CERL		
A.M.A.R.C. (Destruction of Fireworks)		4,516.00
G.S.C. (Development of Tricore Bit Explosive System)		1,351.70
R.C.M.P. (Development of Container to Transport Forensic Explosive Samples)		1,285.00
Grand total		$89,385.00

Total number of billings - 126

Total number of companies - 59

Total number of samples/tests - 526

Total for all cost recovery - $89,385.00

APPENDIX F

PROFESSIONAL, TECHNICAL AND ADMINISTRATIVE STAFF

AND STAFF CHANGES

PROFESSIONAL, TECHNICAL AND ADMINISTRATIVE STAFF

NAME	DEGREES AND DIPLOMAS	OCCUPATIONAL CATEGORY
HEADQUARTERS		
J.E. Udd	B.Eng., M.Eng., Ph.D. (McGill); P.Eng	Director
J.S. Davidson		Secretary
ADMINISTRATION		
E.C. Tupper		Admin. Officer
M. Hamel		Publications
D.M. Hill		Spec. Proj. Officer
S.C. Pollock		Word Processor
C. Sleeth		Finance & Travel
CANADIAN EXPLOSIVE ATMOSPHERES LABORATORY		
J.A. Bossert	B.Sc. (Queen's), P.Eng.	Manager
M.I. Inglis		Secretary
M.J. Boyle	Dipl. (Mech. Tech.) (Algonquin)	Technologist
K.C. Cheng	B.Sc., M.Eng., (Tainan Chen-Kung, Taiwan)	Engineer
E.D. Dainty	B.Sc., M.Sc., (Toronto) P.Eng	Res. Sci.
D.D. Dainty	Dipl. (Inst. Tech.) (Algonquin)	Technologist
J.A.D. Ebersole	Dipl. (Elect. Tech.) (Ryerson)	Technologist
L. Geller	Dipl. Ing. (Mech. Eng.) (Budapest), B.Sc. (Eng.) (London), M.A.Sc. Toronto)	Res. Sci.
K. Judge	B.Sc., (Geology) (Carleton) (Electronics) (Algonquin)	Technologist
G. Lobay	B.Sc. (Manitoba), P.Eng.	Engineer
K.J. Mintz	B.Sc., M.Sc. (UBC); PhD. (Toronto)	Res. Sci.
J.P. Mogan	B.S.Sc. (Toronto), P.Eng.	Res. Sci.
M.J. Ralph	Dipl. (Elect. Tech.) (Algonquin)	Technologist
J.A. Vallieries	Dipl. (Mech. Tech.) (St. Michael's)	Technologist
CANADIAN EXPLOSIVES RESEARCH LABORATORIES		
R.R. Vandebeek	B.Sc., M.Sc. (Carleton)	Manager
J. Campbell		Clerk
R. Augsten	Dipl. (Agri. Tech.) (Jena, Germany)	Technologist
E. Contestabile	B.Sc. (Carleton)	Phys. Sci.
D. Cox	Dipl. (Drilling & Blasting) (Sir Stanford Flemming)	Technologist
T. Craig	Dipl. (Biochem. Tech.) (Algonquin)	Technologist
D. Dinel	Dipl. (Analy. Chem. Tech.) (CEGEP)	Technologist
K.K. Feng	B.Sc., P.Eng., M.Sc., Ph.D. (Iowa)	Res. Sci.
D.E.G. Jones	B.Sc., Ph.D. (Western)	Res. Sci.
P. Lee	B.Sc. (Hong Kong Baptist)	Chemist
E. Nagy	Dipl. (Electr. & Mech. Tech.) (Ryerson)	Technologist
E.T. Pike	Dipl. (Chem. Tech.) (Dawson)	Technologist

ELLIOT LAKE LABORATORY

R.O. Tervo	B.A.Sc. (Toronto), Ph.D. (Bradford);P.Eng.	Manager
F. Lelièvre		Secretary
E. McElrea		Office Manager
J. Nipius		Financial Clerk
A.M. Webster		Rpts. & Publ'ns Clerk
B. Arjang	B.Sc., M.Sx., Ph.D. (Germany)	Res. Sci.
J. Bigu	M.Sc. (Barcelona), DTC (BA++) (Slurry) Ph.D. (Queen's)	Res. Sci.
Y.M. Boucher	Dipl. (Bio Science Tech.) (St. Clair)	Technologist
K.C. Butler	B.Sc. (Laurentian)	Technologist
N.K. Davé	B.Sc., M.Sc. (Rajastan, India), Ph.D. (Queen's)	Res. Sci.
E. Edwardson		Technologies
A.J. Frattini	Dipl. (Inst. Eng. Tech.) (Ind.)	Technologist
M. Grenier	B.Sc., M.Sc. (Laurentian)	Res. Sci.
D. Hanson	B.Sc., Geol. Eng. (Saskatchewan), M.Sc. Geo. Tech (Minnesota)	Phys. Sci.
S.G. Hardcastle	B.Sc., Ph.D. (Nottingham, England)	Res. Sci.
D.G.F. Hedley	B.Sc., Ph.D. (Newcastle), P.Eng.	Res. Sci.
T. Jewiss	Dipl. (Min. Tech.) (Cambrian)	Technologist
G. Knight	B.Sc. (Birbeck, London)	Res. Sci.
T.P Lim	B.Sc. (Ottawa), Dipl. (Radio Chem. Tech.) (Munich, West Germany)	Phys. Sci
P. Rochon	M.Sc., (Montreal)	Phys. Sci.
W. Ropchan	Technology (Cambrian)	Technologist
M. Savich	Dipl. (Min. Eng.) (Ljobljan, Yugoslavia), B.Eng., M.Eng. (McGill)	Res. Sci.
J.A. Smith		Technologist
W. Zawadski		Technologist

CANADIAN MINE TECHNOLOGY LABORATORY

G.E. Larocque	B.Sc. (Carleton)	Manager
J.E. Byford		Secretary
C.D. Baxter		Word Processor
A.B. Annor	B.A.Sc. (Ottawa); M.Eng. (Carleton); P.Eng.	Phys. Sci.
M. Bétournay	B.Sc., M.Sc.A., B.Eng. (McGill); P.Eng.	Phys. Sci.
N. Billette	B.A. (Bourget), B.Sc., M.Sc., Ph.D. (École Polytechnique)	Res. Sci.
A. Boyer	B.Sc. (Montreal)	Phys. Sci.
R. Boyle	B.Sc. (Ottawa)	Phys. Sci.
R.W.D. Clarke	B.Eng. (NSTC), P.Eng.	Engineer
D. Dugmore	Dipl. (Mach.) (CNR); Mech. Draft. (Ontario)	Draftsperson
J. Folta		Draftsperson
A. Füstös	B.S.F./F.E., B.Sc. (UBC); M.Sc. (Carleton); P.Eng.	Engineer
M. Gangal	B.Sc. (Agra, India); M.Sc. (Rorkee, India & McGill); Ph.D. (Calgary)	Res. Sci.

CANADIAN MINE TECHNOLOGY LABORATORY (Cont'd)

B. Gorski	Dipl. (Eng.) (St. Marks)	Technologist
C.B. Graham	B.Sc., M.Sc. (Eng.), (Queen's)	Phys. Sci.
M. Gyenge	Dipl. (Eng.) (Budapest), P.Eng.	Res. Sci.
G. Herget	B.Sc. (Goettingen, West Germany) M.Sc., Ph.D. (Munich, West Germany);	Res. Sci.
F. Kapeller	Dipl. (Ind. Elect.) (Austria)	Technologist
R. Jackson	B.S.Sc. (Waterloo); P.Eng.; AECL Employee	Phys. Sci.
P. Lacourse	B.A.Sc. (Laval)	Engineer
J. Pathak	B.Eng., (Min.Eng.) (Sagar, India), Ph.D. (Freiberg, Germany)	Engineer
N.A. Toews	B.Sc. (Queen's)	Res. Sci.
S. Vongpaisal	B.Eng., M.Eng., Ph.D. (McGill); P.Eng.	Res. Sci.
D.F. Walsh	B.Sc. (Memorial)	Phys. Sci
R.J.R. Welwood	B.Sc. (Queen's)	Phys. Sci.
A.S. Wong	B.Sc. (National Taiwan University), M.Sc. (Ottawa)	Phys. Sci.
Y.S. Yu	B.Sc., M.Eng. (McGill)	Res. Sci.

STAFF CHANGES

APPOINTMENTS AND PROMOTIONS

D. Cox	Technologist - CERL - July 86
J.S. Davidson	Secretary to Director - July 86
L. Geller	Res.Sci. - CEAL - September 86
D.M. Hill	Special Projects Officer - September 86
R. Jackson	Phys. Sci. - CMTL - March 1987
K. Judge	Technologist - CEAL - February 87
F. Lelievre	Secretary - ELL - August 87
N. Sarin	Engineer - CEAL - June 86

SEPARATIONS

Retired

D. Dugmore	December 1986
L. Tirrul	June 1986
H. Poliquin	October 1986
J.P. Mogan	August 1986
M. Ralph	February 1987

Resigned

C. St.Jean	September 1986
A. Makuch	October 1986
J.E. Evans	May 1987

Transfers

C.A. Sabourin	- to RPO September 86

NOTE: C.B. Graham requested an extended leave of absence to accept a position (temporary) with the Ontario Mining Association, Mining Research Directorate.